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WEATHER BUREAU

CHARLES F. MARVIN, Chief

MONTHLY WEATHER REVIEW

VOLUME 43, No. 11

NOVEMBER, 1915

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

NOVEMBER, 1915.

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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Acting Editor.

VOL. 43, No. 11.
W. B. No. 569.

NOVEMBER, 1915.

CLOSED JAN. 3, 1916
ISSUED JAN. 25, 1916

INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW will be prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers, and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1914. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors" are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada,
The Meteorological Service of Cuba,
The Meteorological Observatory of Belen College, Habana,
The Government Meteorological Office of Jamaica,
The Meteorological Service of the Azores,
The Meteorological Office, London,
The Danish Meteorological Institute,
The Physical Central Observatory, Petrograd,
The Philippine Weather Bureau.

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SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING NOVEMBER, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Dec. 22, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University,[1] Washington, D. C., during November, 1915. The means for the month are slightly lower than the five-year means published in the Bulletin of the Mount Weather Observatory, 1912, **5**: 182, Table 3.

Skylight polarization, measured at solar distance 90° and in his vertical, with the sun at zenith distance 60°, averaged 62 per cent, with a maximum of 66 per cent. This latter is the same as the average maximum polarization for November published in the Bulletin of the Mount Weather Observatory, 1910, **3**: 114, Table 16.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during November, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Nov. 3				1.00	0.93	0.86	0.80	0.74	0.67	0.63	0.62
5			1.02	0.92	0.80	0.73	0.65	0.59	0.54	0.51	0.47
6			1.22	1.09	1.00	0.93	0.87	0.82	0.77	0.72	0.67
9			0.94	0.83	0.77	0.71	0.66	0.61			
10			1.34	1.26	1.19	1.13					
16						1.12	1.04	0.96	0.91	0.86	0.81
19			1.34								
20			1.27	1.19	1.11						
22			1.26	1.18	1.11			0.91	0.86	0.82	
26			1.18	1.05							
29			1.25	1.30							
Means			**1.20**	**1.09**	**0.99**	**0.91**	**0.80**	**0.77**	**0.75**	**0.71**	**0.64**
P. M.											
Nov. 1			1.03	0.87	0.75	0.66	0.59	0.51	0.45		
6			1.19	1.08	0.99	0.92	0.84	0.78	0.71		
9			1.24	1.11	1.01	0.90	0.77	0.64	0.53		
10			1.34	1.26	1.19						
16			1.32								
20				1.25							
22			1.28	1.18							
26			1.18								
27			1.25	1.23	1.14	1.05	0.98	0.91	0.85	0.81	0.79
30			1.27	1.16							
Means			**1.23**	**1.14**	**1.02**	**0.88**	**0.80**	**0.71**	**0.64**	**(0.81)**	**(0.79)**

[1] For a description of exposures of instruments and details of observation see this REVIEW, December, 1914, **42**: 648.

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University during November, 1915. The measurements were made with a Calendar recording pyrheliometer, as described in this REVIEW, March, 1915, **43**: 100. Table 2, column 3 gives the daily departures from the normals published in the same number of the REVIEW, page 111, Table 4.

The "Percentage of possible sunshine" and the "Average cloudiness," given in columns 5 and 6, Table 2, have been taken from the records of the observatory of the central office of the Weather Bureau. The monthly mean percentage of possible sunshine is 71, as compared with a normal for November of 54 per cent.

TABLE 2.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during November, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.	Departure from normal.	Excess or deficiency since first of month.	Percentage of possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0-10.*
Nov. 1	295	46	46	93	4
2	268	22	68	93	3
3	246	2	70	96	3
4	103	−138	− 68	19	8
5	230	− 8	− 76	79	4
6	312	77	1	100	0
7	301	69	70	100	0
8	235	5	75	74	4
9	280	53	128	100	0
10	296	72	200	98	2
11	226	5	205	67	9
12	123	− 96	109	21	6
13	268	52	161	94	5
14	49	−164	− 3	0	10
15	200	− 10	− 13	61	6
16	261	53	40	93	4
17	267	61	101	100	0
18	246	43	144	79	4
19	192	− 9	135	60	7
20	243	44	179	85	4
Decade departure			− 21		
21	121	− 76	103	32	8
22	266	72	175	94	1
23	104	− 87	88	0	10
24	219	30	118	79	4
25	201	14	132	67	5
26	221	36	168	77	4
27	181	− 3	165	61	4
28	213	31	196	78	4
29	161	− 20	176	22	7
30	226	47	223	94	3
Decade departure			44		
Total excess or deficiency since first of year			−1,481		

The above data indicate more than the usual number of hours of sunshine during November, but radiation intensities slightly below the average for the month. There was a slight deficiency of radiation during the second decade, but an excess during the other two, the excess being pronounced during the first decade.

INCREASED SOLAR ACTIVITY AND ATMOSPHERIC OPTICAL PHENOMENA.

By J. MAURER.

[*Translated from* Meteorologische Zeitschrift, November, 1915, 32:515-7.]

Further observations on the circumsolar haze corona[1]—carried out more carefully and more frequently since the beginning of this year—have yielded some most interesting results during the past summer, concerning which I here wish to publish a preliminary report, having already referred to them in Astronomische Nachrichten, No. 4813.

Recent studies and views, as is well known, have brought us to regard the sun and particularly his regions of greater activity which appear as faculæ and spots, as a mighty source of cathode radiation. At the well-known times of increased solar activity, particularly, tremendous quantities of little particles charged with negative electricity are discharged into space in the form of the rapid cathode rays, and they even invade our atmosphere, thereby giving rise to our auroral and terrestrial magnetic phenomena, according to Birkeland's theory.[2] P. Lenard, of Heidelberg, recently gave us in volume 28 of the Meteorologische Zeitschrift for 1911, a very graphic exposition of the detailed nature of these cathode rays from the sun with respect to their velocity, their magnetic deflection, and particularly their absorbability in the terrestrial atmosphere. From Störmer's [3] determinations of the lowest altitudes for the aurora, which descends to about 35 km. above the earth in our atmosphere, Lenard has already been able to compute a limiting value and also a probable absolute value of the atmospheric absorptiveness for the auroral cathode radiation. In the following I would draw attention to another form of the phenomenon of solar cathode rays in the earth's atmosphere, which touches on that portion of the actually still present electron-radiation that enters the atmosphere on the daylight side of the earth.

I have long been convinced that at times of considerably increased solar activity and precisely by reason of its cathode radiation, the latter makes known its presence during daylight by causing a special kind of aureole about the sun. A priori I expected to find it a ring-phenomenon of a somewhat large diameter, which theoretically would considerably exceed that of Bishop's Ring. Careful observations, in the company of my tireless colaborer Capt. Friederich Schmid in Oberhelfenswil, St. Gallen, upon the interesting circumsolar haze disk have further fostered this conviction.[4] The occasion of the rapidly increased solar activity of the first semester of the present year, seemed to offer a favorable opportunity to soon settle the question, perhaps, by giving redoubled attention, since my highly esteemed colleague, Prof. Wolfer, director of the Federal observatory, expressed a willingness to assist me in the principal matter of keeping fully abreast of the current sun-spot activity. This careful, systematic and simultaneous check against all the rapidly changing current occurrences in the sun, which we can call upon at any instant, is of the greatest importance.

First with the days from June 13 to 16, 1915, came the critical period, viz, a rapid pronounced increase in the formation of sun-spots [5] whereby the majority of the spot groups were newly formed, quite in contrast to the immediately preceding interval from June 4 to 13 which showed a pronounced period of rest throughout the whole spot zone. This was a particularly favorable moment.

Director Wolfer's kind communications of his daily solar survey showed very definitely that particularly about the middle of June (n. b.—the 13th to the 16th) numerous newly formed disturbances developed on the solar surface which then pointed to an almost simultaneous reawakening of activity throughout the sun-spot zone.

On June 16, from 2 to 3 p. m., I could for the first time detect with certainty a delicate, clearly marked brown fringe about the sun having a full maximum width of about 15° and projected against the marked haze disk of 70° diameter which surrounded the sun. The sky appeared blue, but showed, as it had for some days before (since June 12), a certain dirty hazy trace which was itself the sign of a slight atmospheric optical disturbance. We also had the sensation that even beyond the zone of that remarkable brown fringe of the haze corona, the whole sky had a somewhat striking veiled appearance. Prof. Wolfer added, for my benefit, the following note to his solar survey of June 19:

> During the last few days I have been repeatedly impressed by the veiled appearance of the sun, which hindered the observation of the spots and faculæ, although neither true clouds nor the light veil of haze were present. On the projection of the solar image the latter's color was a pronounced white-gray. To-day, June 19, the phenomenon is more striking than ever for the image is again heavily veiled, but of a pronounced yellow-gray, with a tone of reddish.

At noon on June 17 the above-mentioned brownish corona was no longer perceivable and the sky also seemed to be again of an irreproachable blue. On August 3 Capt. Schmid looking from his 900m. high location, which is wholly free from dust and smoke, again had the impression that there was a very delicate brownish tinge to the solar haze disk at very nearly the time when one of the larger spot-groups crossed the solar meridian; and the same experience recurred for the third time on August 19 when the outer half of the solar haze disk for a width of about 20° again showed a reddish brown, very delicate tone. In general there was also a very marked resemblance to the June phenomenon, in the considerably increased solar activity by reason of which two groups of spots accompanied by considerable new formations again crossed the sun's center.

The rapid development and disappearance of the corona here described argues against its being of the nature of an aureole produced intermittently by volcanic dust at high levels, etc. In this matter it is specially significant that on the night of June 16–17 Prof. Barnard at the Yerkes Observatory observed an auroral display [6] and that elsewhere there were also important magnetic disturbances as well as earth currents in North America. On this occasion from June 16 to 17 of this year, therefore, we undoubtedly had to do with an extensive influence of solar cathode rays, and it is hardly to be accounted an accident that at precisely the same time there appeared this brown aureole about the sun.

---

[1] An introductory report appeared in the Meteorologische Zeitschrift, März, 1915, 32: 114–118.

[2] See this REVIEW, April, 1914, 42:209.

[3] *Karl Störmer:* Ueber einige Resultate photogrammetrischer Messungen der Nordlichthöhen zu Bössekop im Februar und März, 1910. Meteorol. Ztschr., 1911, 28:487–8.

[4] Compare summary by Jensen in MONTHLY WEATHER REVIEW, March, 1914, 42: 144.—C. A., jr.

[5] This rapid increase, almost a jump, in the number of sun spots during the critical June period is best expressed by the Wolfer provisional relative sun-spot numbers for June, 1915:

Day	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Relative number	9	8	7	7	23	61	72	117	139	146	149	177	154	145

[6] "Nature" (London), June 24, and July 15, 1915 *See also* abstract in this REVIEW, September, 1915, p. 445; this issue of the REVIEW, p. 546.

We shall have occasion in the future to further consider this interesting matter, in order to point out that at certain epochs of increased spot activity the resulting solar cathode ray influences produce special ring phenomena about the sun. In meteorological optics, however, these peculiar solar aureole displays will assume a special position, and later theory will have to discuss them in more detail.

A few years ago it was pointed out that there is a supposed relation between solar activity and certain phenomena in atmospheric optics. Jensen and Busch in their fundamental work [7] have attempted to further establish the opinion, expressed by Busch as early as 1893, that there is perhaps a paralellism between the secular march of the neutral points of Arago and Babinet and that of the solar activity. From the preceding paragraphs it is scarcely to be doubted that, particularly about the time of the maximum in periods of specially augmented activity, this relation actually does exist. A close comparison, as nearly synchronous as possible, between regularly executed observations of atmospheric polarization and the momentarily existant solar activity will also bring to light many interesting features. But much depends on the relative direction from which the solar emanation impinges on the earth's field and the atmosphere, and on the atmospheric conditions found at the different points on the earth. There are often considerable *local* variations in the individual forms of the phenomena.

AURORA OF JUNE 16–17, 1915.

By DOUGLAS F. MANNING.

[Dated: Alexandria Bay, N. Y., June 20, 1915.]

Several days ago I sent you a few observations on an aurora and I thought that you might be interested to learn that on the following evening there occurred a much more pronounced display which, from the inclosed clipping, must have been quite general.

[Clipping from ——.]

NEW YORK, *June 17, 1915.*—The electrical disturbance caused by the aurora borealis in the northwest last night [June 16, 1915] had a serious effect on cable and telegraph lines in the northeastern part of the United States and eastern Canada. For several hours during the early morning cable communication via the Newfoundland cables of the Western Union was all but paralyzed and the disturbances, although they diminished, were still felt up until the late afternoon.

A peculiar feature of the phenomenon was that only east and west wires were affected. Interruptions in land-line service were frequent, the wires being heavily surcharged with electricity.

The telegraph systems of the Commercial Cable Company and of the American Telephone & Telegraph Company were similarly affected. Officials of the latter company said the disturbance was felt as far south as Pittsburgh and particularly around Buffalo, although the interruptions were of short duration. * * *

The disturbance was not unprecedented, * * * but nothing so severe had occurred in 11 years.

On the evening of June 17 the aurora appeared in patches of greenish light without any particular formation, but it seemed much closer to the earth than I have ever seen it. The patches of light extended all over the northern sky, reaching overhead and occasionally to the south of the zenith; the leading feature was the tremendous speed of the light "waves" which would continually flash up from the north, the different patches lighting up and fading out in quick succession; sometimes one of the patches would show a tinge of red and yellow when at the height of its brilliancy. There were no clouds whatever present. * * * The local wireless man here had great difficulty in securing his evening reports, he claims. During the evening I turned my compass so that the needle read due north and south on its card, and on the following morning I noted that the needle pointed about 2° east of north; I am very sure that no one could have disturbed the compass box to cause the variation.

The following morning the sky was streaked with cirrus streamers, as I have so often observed after an auroral display, and it really seems as though there were some connection between the two. The cirrus streamers generally follow an aurora and are not always present during the display; the sky on the evening in question was absolutely clear and right in the heart of a "high."

[7] *Busch & Jensen.* Tatsachen und Theorien der atmosphärischen Polarisation. Hamburg, 1911. 8°.

AURORA OF JUNE 16–17, 1915, AT ASHLAND, OHIO.

Mr. S. W. Brandt, our cooperative observer at Ashland, Ohio, sent to the Weather Bureau office in Columbus, Ohio, the following account of the great aurora of the night of June 16–17, 1915:

417 VINE STREET, ASHLAND, OHIO,
*June 16, 1915.**

I am a night watchman and have just come in from the 2 o'clock [a. m. June 17] trip, having had the rare privilege of beholding the most beautiful display of northern lights that I have witnessed for many years.

The sky here has been clear of clouds all night, except a low ridge far to the north [no moon] and the view unobstructed. I first noticed the light in the north as soon as it became dark. At 11 p. m. it became very brilliant, with a primary bow far to the north and a secondary bow about midway between this and the zenith. This secondary bow extended from the far east to the far west. Streamers of white light extended from the primary bow, in a vertical position nearly to the zenith.

It was less brilliant until 2 a. m. when it became more beautiful than at any other time during the night. The secondary bow had disappeared, although the vertical streamers were still playing, and over all these from the primary bow far to the north came great waves of brilliant white light many times reaching to the zenith. They just resembled the waves of the ocean rolling out upon a low beach.

At 2:30 a. m. the secondary bow had again appeared.

At 3 a. m. [June 17] daylight had so far advanced as to render the aurora invisible.

STUDY OF THE UPPER AIR BY MEANS OF TELESCOPES.

Those of our readers who were interested in the paper by Prof. W. H. Pickering in this REVIEW for October, 1915, will find added interest in a longer article on the subject by Prof. A. E. Douglass published in the American Meteorological Journal for March, 1895 (vol. 11, no. 11). It is regretted that this reference escaped the Editor last month.—C. A., jr.

* A later letter shows that this account was written June 17, 1915—C. A. jr.

SECTION II.—GENERAL METEOROLOGY.

WORKING UP OF WIND OBSERVATIONS.

By J. W. SANDSTRÖM.

[Dated: Stockholm, Sweden, Aug. 17, 1915. Statens Meteorologiska Centralanstalt. Translated by H. Ball and C. Abbe, jr.]

Among the magnitudes observed and recorded by meteorologists the wind is the only one that possesses vector qualities. All the rest are scalar quantities. In discussing wind observations this distinction must be considered.

An important method of working up meteorological elements consists in deducing the monthly means of the same. The average, as every one knows, is obtained by taking the sum of the observations for the month and dividing it by the number of observations. To secure such an average for the wind, the sums of the wind vectors are taken and divided by the sum of the observations; the result obtained is the mean wind vector for the month.

There are various ways of determining the vector sums. One can proceed numerically by resolving the wind vectors into components referred to two mutually perpendicular axes, adding the components of either axis and finally combining the sums into a vector. One can also employ graphical methods, combining the wind vectors according to the law of parallelograms or constructing a polygon. Finally the sum can be ascertained mechanically by weighing or by plotting. I have tried all of these methods and have found that the last-named leads most quickly and most easily to the desired result.[1]

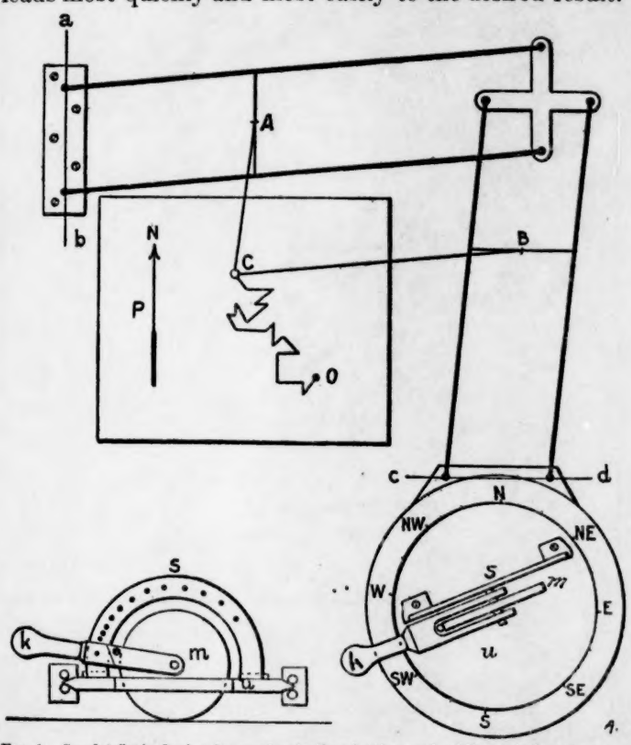

FIG. 1.—Sandström's device for mechanically plotting and adding wind vectors.

I will describe this process more in detail. Figure 1 shows a parallelogram linkage mounted on a drawing board so that the line *cd* always remains perpendicular to the fixed line *ab*, whatever the position of *cd*. A circular rim bearing the wind directions is connected with *cd*. This circle can be moved across the board in any direction but can not be rotated. The north-south direction of the circle always remains parallel to the fixed line *ab*. Within the circular rim and in its plane, lies a circular disk *u* which runs in a ball bearing in the inner edge of the circle and consequently can be set for the different wind directions by means of the handle *k*. A slot in the disk *u* accommodates the vertical wheel *m*, which can be made to turn by a friction clutch when we raise the handle *k* but remains stationary when *k* is lowered. Since the apparatus rests upon the wheel *m*, its movement is regulated by the movement of *k*, which is controlled by the scale *S*, on which the wind forces have been inscribed.

On the parallel linkage is a pantograph arrangement *ABC*, carrying a pen at *C*, which registers the movement of the apparatus in a reduced diagram *OC*. The curve *OC* then includes both the individual vectors and their sum.

The ruled paper on which the curve is traced is so oriented that its lines will coincide with the north-south direction of the instrument, and as a check the north-pointing arrow *P* is drawn before beginning to draw the vector diagram *OC*. If we imagine the points *O* and *C* in figure 1 connected by a straight line the direction and length of this line is the sum of all the small vectors of various directions which are drawn between *O* and *C*. For reading off these vector sums I have a special scale which is used like a protractor. (See fig. 2.) The circle of the protractor is divided into 40 parts, so that 0 or 40 represents the east direction, 10 the north, 20 the west, and 30 the south direction. Thus the tens indicate directly the quadrant of the vector direction.

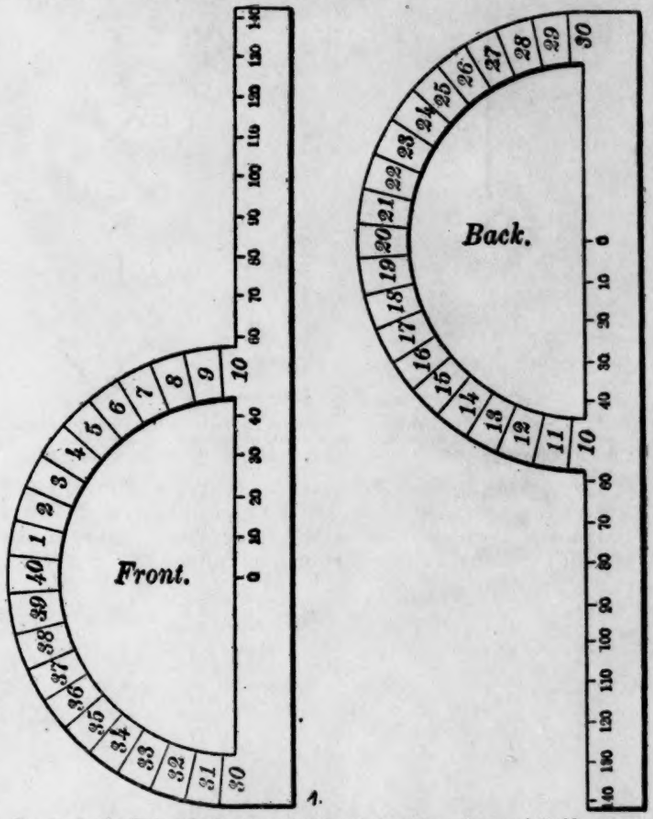

FIG. 2.—Sandström's scales for measuring the wind vectors and sums plotted by means of the device shown in figure 1.

The length *OC* represents the sum of the vectors. In my apparatus I have so chosen the scale *S* of figure 1 and the reduction *ABC* that a wind velocity of 1 meter per second corresponds to 0.5mm. on the curve *OC*. The length *OC* will be measured by a corresponding scale. If, for example, one wishes to compute the total wind

[1] Descriptions of some other devices for determining wind resultants are given in this REVIEW, December, 1897, 25: 540, ffg.—EDITOR.

movement for the month from the daily 8 a. m. observations, he will, of course, multiply the vector sum by 86,400. This factor can then be appropriately considered in constructing the scale so that one may read off the wind movement directly in kilometers. This sum divided by the number of days in the month gives the average air movement for 24 hours, which is conveniently entered on the monthly chart as an arrow drawn to scale so that one can see directly the amount and direction of the average daily wind movement. The labor is light, simple, and quite mechanical when the appropriate scales are computed, and is suitable for women.

In working up older observations one may appropriately plot the observations for the entire year on one sheet, indicating the different months by their proper numbers, as shown in figure 3 and Table 1.

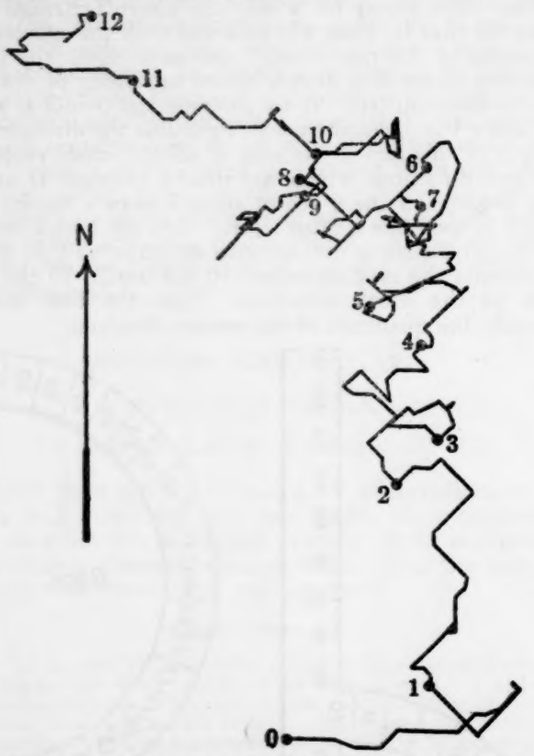

FIG. 3.—Tracing by the device shown in figure 1. Data: Wind vectors for Skara, Sweden, 1910. Nos. 1, 2, 3, etc., indicate ends of plots for respective months; the line 0–12 gives direction and mean wind movement for the station for the year.

In working up more recent observations the wind diagrams for several stations for the month in question may be plotted side by side on the same sheet. The results would be shown in tabular form as follows—

TABLE 1.—*Results of wind observations at Skara in 1910.*

[Lat. 58° 24′ N., long. 13° 27′ E. Altitude, 115 meters.]

[Compare plat in fig. 3.]

Month.	Direction of movement.	Magnitude of movement.	Mean 24-hour movement.	Mean movement.
	Figure 2.	*Km.*	*10^4 meters.*	*M/sec.*
I	2	3,800	12	1.4
II	11	5,200	19	2.1
III	5	1,400	5	0.5
IV	11	2,400	8	0.9
V	16	1,700	5	0.6
VI	7	3,700	12	1.4
VII	29	1,200	4	0.4
VIII	18	3,300	11	1.2
IX	32	400	1	0.2
X	8	1,100	4	0.4
XI	18	5,100	17	2.0
XII	14	1,900	6	0.7
Year	12	16,900	4.6	0.54

and then entered on the monthly maps. It will be convenient in this procedure to represent the monthly wind values as arrows whose lengths show the mean air movement for 24 hours, according to the scale of the map. Of course the lengths of these arrows will be quite independent of the units (kilometers or miles) used in computing them.

Figure 4 shows a wind chart of Europe for January, 1913, made in this way. The regularity and continuity of the independently determined vectors on this chart is a proof of the reliability of the method.

This method has been little used heretofore and will give us many new ideas concerning meteorological phenomena. In order to prove this I will discuss the charts somewhat more fully. Heretofore it has been held generally that the prevailing winter winds of Europe were southwesterly because the winter climate of Europe is [supposed to be] very much dependent on the temperature of the Gulf Stream of the North Atlantic Ocean. The air temperature in Sweden is indeed in winter 12°C., in Finland 10°C., and in Germany 8°C. higher than the normal mean temperature for the latitude. Also Prof. O. Pettersson has clearly and incontrovertibly proven that during the years in which the North Atlantic Gulf Stream was specially warm, the climate [weather?] of Europe was also mild, and vice versa.

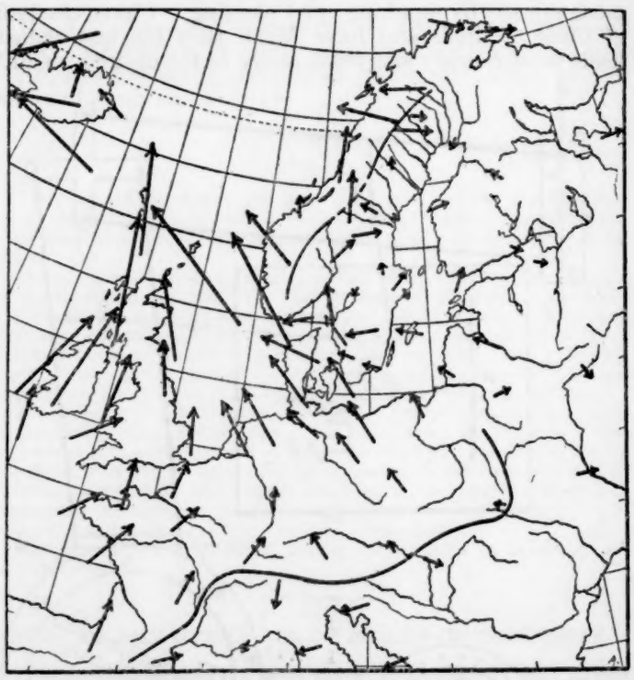

FIG. 4.—Mean 24-hour surface wind movement and direction in January, 1913, over western Europe. (Wind movements are indicated by length of arrows according to the scale of the map.)

The map, figure 4, shows that, at least in January, 1913, the air did not move from the southwest to the northeast, but rather from the southeast to the northwest. The air that overflowed Scandinavia and Germany in January, 1913, therefore did not come from the Atlantic Ocean but from the interior of the continent. Yet Europe was far warmer in this month than the normal mean temperature for its latitude.

We are thus obliged to think that the warmth from the North Atlantic Ocean is not carried to Europe by the surface winds but by those at higher levels. We may liken Europe and the North Atlantic Gulf Stream to a room with a stove in its northwest corner. When the stove is heated the warm air rises and spreads itself over

the upper part of the room, gives off its heat, and then sinking, follows the floor back to the stove. Thus a warmer northwest wind blows along the ceiling of the room and a cold southeast wind blows along the floor, as may be easily proven by the use of tobacco smoke and a thermometer. Similarly, during the winter a warm northwesterly wind will blow at high altitudes over Europe and colder southeasterly winds will move along the surface. It is this lower southeasterly wind that appears on the chart, figure 4.

A vertical section through the atmospheric circulation between the North Sea and the Alps in January, 1913, would therefore appear somewhat like figure 5. Dr. O. Krogness, director of the mountain observatory on Haldde, 900 meters high, on the northern coast of Norway, has sent me a large number of observations, among others those of January, 1913, which lend great support to this concept of the air circulation over Europe. At Haldde the wind was quite predominantly from the northwest, while at the base of the mountains a southeasterly wind predominated. At the same time the air temperature was several degrees higher at the summit than at the base. Evidently the air warmed over the sea flowed toward the continent at a high altitude while the cold air from the continent flows seaward beneath it.

At Haldde the surface dividing the upper warm from the lower cold air currents stands at an altitude of less than 900 meters. Farther inland, in the Swedish mountains, I have found this surface at an altitude of about 1,200 meters, while it appears from kite and balloon observations at Lindenberg that it there lies between 2,000 and 3,000 meters high. It is therefore inclined and dips toward the warm sea as is indicated in figure 5.

FIG. 5.—Atmospheric exchange in winter between Europe and the North Atlantic ocean.

I have produced this dividing surface experimentally on a small scale and there also have found that it is inclined.[2] Because of the temperature inversion and the sudden change in density at this surface as well as its oblique position it embraces a great number of Bjerknes solenoids. If we estimate the heating of the air over the North Atlantic Ocean at 9°C. and put the difference of altitude of the dividing surface from the Alps to the North Sea as 3,000 meters, then the surface will contain about 10^7 solenoids.

According to figure 4, the mass of air flowing to the North Sea may be estimated as 5 cubic kilometers per second or 5×10^6 metric tons, which would give an energy of about 7×10^9 horsepower.[3]

In the circulation indicated in figure 5, the air is thus seen to pass through a Carnot cycle, by means of which this enormous amount of energy is transformed from heat into wind. It is therefore this tremendous amount of energy that maintains the great air circulation between the North Atlantic Ocean and Europe and at the same time moderates the winter climate of Europe. It is also this circulation that causes Europe's winter storms and winter precipitation. This wind-making machine is surely well worth investigating.

Having revealed, by means of the map, figure 4, the probable cause of the mighty southeasterly air current across Europe during January, 1913, we will consider still other details of the chart. The first thing that attracts our attention is that the air flows outward on either side of all mountain ranges. From the Alps it flows both southward to the Mediterranean and northward to the North Sea; from the Carpathians eastward toward the interior of Russia as well as westward to the North Sea; from the Scandinavian ranges westward toward the North Sea as well as eastward toward Finland. The cause of this outflow from the mountain regions is evidently thermal radiation skyward which cools the mountains and also the air in contact with them. By this means the specific gravity of the mountain air becomes greater than that of the surrounding air and sinks through it, following the mountain sides. Furthermore, we see that the broad warm seas possess considerable aspirating force. Even the Mediterranean draws a considerable mass of air toward itself, but the warm North Atlantic Ocean draws the greatest quantity. This aspiration is evidently due to the warming of the air over the warm oceans, whereby it becomes specifically lighter and is pushed upward by the surrounding denser air that pushes in beneath.

This descent of the cooled air from the mountains and forcing upward of the warmed ocean air evidently sets up the circulation shown in figure 5. We can picture the process as follows: The temperature conditions first produce a special pressure distribution as the vertical interval between two isobaric surfaces is always proportional to the absolute temperature of the intermediate air, therefore the isobaric surfaces lie closer together in the cold mountain region than over the warm sea. The result is that the pressure gradient at lower altitudes is from the mountains toward the sea, while at higher levels it is in the opposite direction. At the surface of the earth the air will flow, therefore, from the mountains toward the sea and at the higher levels the air flows from the sea toward the mountains.

The cold, heavy air flowing down from the mountains thereby generates kinetic energy just as does a river flowing from a higher to a lower level. Like results are produced by the light air ascending over the ocean. The enormous mass of air and the considerable difference of level produces the great amount of wind energy resulting from the movement. It is clear, however, from this that the cooling of the air must occur at levels higher than where the warming takes place, otherwise no permanent circulation can result therefrom. For this reason no air circulation takes place between the warm North Atlantic Ocean and the Arctic ice. The higher the source of cold lies in comparison with the source of heat, the more intense the air circulation will be.

The outflow from the mountains and the aspiration by the sea, shown in figure 4, naturally also occur in other parts of the earth. The warm North Atlantic Ocean is surrounded by a whole series of mountain ranges—the Pyrenees, Alps, Carpathians, Scandinavian ranges, and those of Spitsbergen and Greenland. Between the North Sea and each of these mountains there is without doubt an air circulation similar to that shown in figure 4. It may be compared with a kettle that is

[2] *Sandström.* The origin of the wind. MONTHLY WEATHER REVIEW, April, 1915, 43: 161-163.
[3] *Sandström.*, op. cit., p. 163.

heated under its center. The water in the pan then begins to circulate. It becomes warm in the center, rises to the surface, spreads out to the sides of the kettle where it is cooled, and sinking follows the bottom back to the center. (See fig. 6.)

way of the North Sea these Norwegian falling storms would evidently become of much greater intensity and longer duration. We thus see how considerable is the influence of topography on the occurrence of storms.

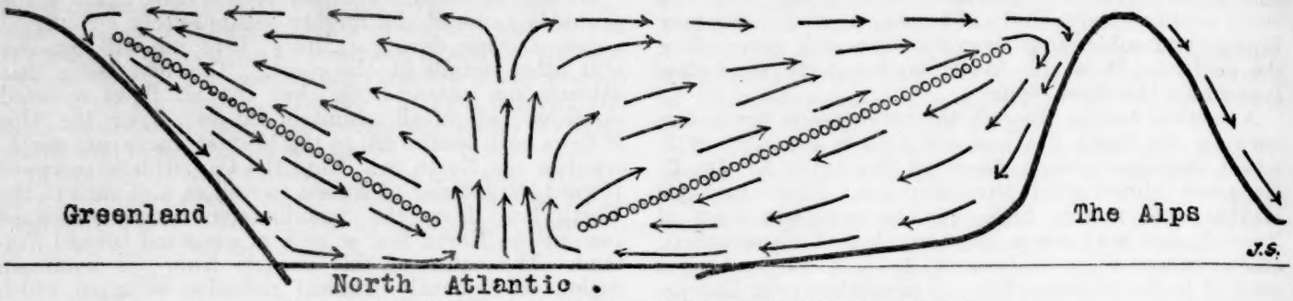

FIG. 6.—Vertical section through the atmospheric circulation over the North Atlantic in winter.

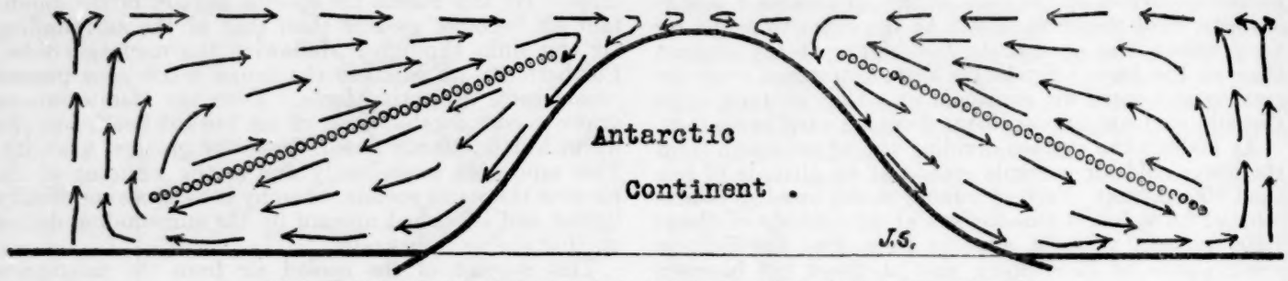

FIG 7.—Vertical section through the atmospheric circulation about Antarctica during the southern winter.

We find another condition in the South Polar region. Here the cold mountains are at the center, surrounded by the warm sea. But here also the rule holds that the air from the cold continent flows outward on all sides, following the surface. On the surrounding oceans the air is warmed and saturated with water, after which it rises and moves along the higher levels to Antarctica whose ice fields are fed by its moisture. (See fig. 7). The extraordinarily constant southwest wind which the Swedish South Polar Expedition of 1902–1903 met with here during the antarctic winter, maintained for weeks a velocity of 20 to 30 meters per second and indicates that the cold seaward-moving air current must be of great depth and strength.

We should then notice somewhat the details of figure 4. We see how the southeasterly air current prefers the easiest way across the North Sea and how it curves around the south end of mountainous Norway. In the narrow passage between Norway and Scotland the air movement is strongly accelerated. On the east side of the Scandinavian mountain range the heavy cold air piles up and forms a sort of aerial lake, with small velocities generally directed eastward. However, in the middle of this extended mountain range at Storlien, where its summit is lowest, the air flows westward from the east side of the ridge also. Evidently here the continental air overflows the ridge. Sometimes probably a portion of the cold-air sea dashes over the higher part of the range also and rushes down the west side of the mountains. These are the times of the extraordinarily violent easterly storms which I have met with in that region in winter and which stopped just as suddenly as they started.[4] Were it not for the open sluice-

[4] *Sandström* in Bull. Mt. Weather Observatory, Washington, 1912, 5: 84–85.—EDITOR.

Many other important conclusions may indeed be drawn from the map in figure 4. What has already been done should be sufficient to awaken in the reader interest for a rational method of working up wind observations in different countries and at different seasons. This is the object of the present paper.

WATERSPOUTS OBSERVED OFF CAPE SAN LUCAS.

By WILLARD J. FISHER.

[Dated: New Hampshire College, Durham, N. H., Nov. 27, 1915.]

The following is an extract from my log on a voyage from New York to San Francisco last summer [1915] on the steamer *Kroonland*. The directions are approximate compass directions, taken with a pocket compass on the bows of an iron ship. Unfortunately, my supply of photographic films was exhausted and I could take no pictures. The sketches, figures 1 to 3, were made in my log immediately after dinner on the day of the observation; faithful tracings of them are reproduced here.

July 22, 1915:

ϕ=17°40′ N., λ=102°36′ W. at noon.

July 23, 1915:

ϕ=20°46′ N., λ=107°36′ W. at noon.

Crossing the broad entrance to the Gulf of California. Saw, 9 a. m. to 11:30 a. m., two long banks of clouds, extending N.–S. clear out of sight, moving about W., as they were several miles apart and they were caught up with, but only slowly. They were cumulus clouds; a section looked about like that shown by figure 1, which is looking northward. The air currents which fed them seemed to move as the dotted arrows. From below there hung down tornado funnels of various sizes and various stages of development, from mere pimples to long well-grown vortices; but none of them reached more than halfway to the sea. From one cloud a smart shower fell on us as we passed under. The funnels were formed where the upward growth of the

bank was particularly vigorous; at such a place there might be a good many or a few or but one; the fewer, the bigger and better developed. They grew downward toward the sea from the cloud base in all cases.

FIG. 1.—Cumulus cloud with whirling mist filament, *x*, seen at entrance to Gulf of California, July 23, 1915.

I had a chance to see one very well. It lay like the arrow in figure 1, about which I have drawn a spiral line. (Fig. 1, *x*.) With the glass I could see the whirling filaments of mist, but they were not dense enough so that I could tell on which side they were, the near or the far, and so determine the direction of the rotation. The pattern was something like that shown in figure 2.

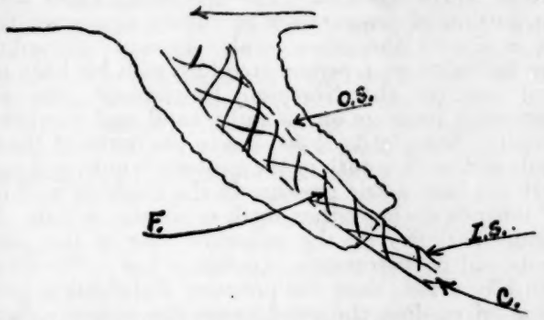

FIG. 2.—Details of the whirling mist filament of figure 1: Upper arrow shows westward direction of motion of the cumulus. *OS*, the outer less dense sheath, growing downward and following the inner sheath, *IS*. The external outline of *OS* was quite vague. *IS*, inner dense sheath, growing downward more rapidly than *OS*. *C*, the hollow empty core. *F*, mist filaments whirling and ascending, seen one through the other so as to give a lattice pattern.

Some of the funnels were so near the rear edge of the cloud as to be illuminated by sunshine; most were in shade, particularly the one above sketched was. The variations in form were from that of "A" to that of "B" in figure 3. Incipient forms were mere protuberances on the cloud base.

FIG. 3.—Limiting forms of whirls under cumulus clouds. A, seen from ahead of the cloud; very large, and reaching one-fourth of the vertical distance to the waves.

These two cloud banks seemed to join in a great cumulus bank far to the south.

July 24, 1915:

$\phi = 24°12'$ N., $\lambda = 112°14'$ W., at noon.

The dotted lines in the first figure were drawn from a comparison of the motion of mist wreaths in the clouds and the way the various tornado funnels lay below the clouds; they could not, of course, be drawn from direct observation.

I also saw a perfectly developed waterspout in the neighborhood of San Salvador [$?\phi = 0°$, $\lambda = 91°$ W.?].

CIRCULATION AND TEMPERATURE OF THE ATMOSPHERE.

By WILLIAM HENRY DINES, B. A., F. R. S.

[Dated: Meteorological Office Observatory, Benson, Wallingford, England, Nov. 1, 1915; received Nov. 17, 1915.]

Meteorology has made great progress during recent years and many of the ordinary phenomena connected therewith have met with simple and satisfactory explanations, but it must be confessed that the circulation of the atmosphere, the basis on which all meteorology depends, remains more or less a hopeless puzzle.

The circulation is due to unequal cooling and heating of different parts of the earth's surface, about that there can be no doubt whatever, the difficulty comes in as soon as we try to see what should be the natural result of this cooling and heating.

Disregarding for the present the local circulation, the moving cyclones and anticyclones, the facts to be explained are the trade winds, the high-pressure belts lying poleward of the trades, the strong westerly winds of temperate latitudes and the low pressures on their poleward side.

It might seem, at first sight, as though a mathematical solution might be obtained, but the difficulties are very great. It is hardly likely that any solution could be satisfactory which did not take account of the humidity of the air, since the latent heat set free by the formation of rain is enormous, and when the humidity and the viscosity are added to the difficulties due to the friction of the earth's surface and the disturbance due to the earth's rotation, the difficulties seem to render a solution hopeless. Notwithstanding, it is a matter of regret that of the few men gifted with very exceptional mathematical ability who appear from time to time, none have made a special study of the subject. While full mathematical treatment is at present impossible certain elementary mechanical principles are fundamental, however, and must be understood before any intelligent discussion of the problem can be commenced. For the elucidation of these principles meteorologists are greatly indebted to Ferrel who, in my opinion, has done more for theoretical meteorology than any one else.

In considering the circulation of the atmosphere the first point that meets us is the effect of the earth's rotation upon a moving body, in this case upon the moving air. In one sense the effect is small, but the cumulative effect is very great. The following seems the simplest way of stating the effect. A body moving freely is subject to a continual change in its direction—in the Northern Hemisphere it turns to the right, in the Southern to the left. It does not matter which way it is moving, east or west, north or south, and it does not matter, within the limits of ordinary wind velocities, how fast it is moving; if moving freely, its direction of motion will gradually turn to the right [in the Northern Hemisphere]. The amount of change or the deviation is proportional to the time and to the sine of the latitude, and the change of direction in one hour is given in degrees by the expression $15 \sin \phi$. Thus in latitude 45°, since $\sin 45° = 0.71$ the change per hour is $10\frac{1}{2}°$, and a little under 9 hours, suffices to turn, in the Northern Hemisphere, an east wind into a south, or in the Southern Hemisphere into a north wind.

Suppose then that a place, *A*, lies north of place *B*, and that for some reason the barometer at *B* is lower than at

A. The natural result is that air flows from *A* to *B*, that is to say, there is a north wind blowing over the country between *A* and *B*, but in nine hours' time the earth rotation has shifted this north wind into an east wind. But as soon as any east appears in the wind, it is ceasing to move freely, since the pressure gradient is turning it back to the south, and as soon as it becomes a true east wind the pressure gradient exactly opposes the tendency to turn to the right, and we find in practice a steady east wind blowing across the line *AB*.

In recent years it has become a common practice to observe the upper winds by means of pilot balloons and it is a fact well established by observation that, within the limits given by the probable errors of observation, the wind at a height of one or two thousand feet is always blowing at right angles to the pressure gradient and that its velocity is proportional to the steepness of the gradient and has the value that is theoretically required. Now it is perfectly easy to explain the trade winds on this principle, but the irony of the situation is that it would be still easier to explain strong east winds in temperate latitudes on the same principle, but unfortunately for the explanation it is strong west winds and not east winds that prevail.

The explanation of the northeast trades commonly given is this. The sun standing vertically over the Equator makes the Equator hotter than the region of 20° or so north latitude, the warm air rises by virtue of its warmth and less density, the cold air from the north flows in to take its place [1] and this flow of air from the north or north wind is turned by the tendency of the earth's rotation into an east wind, and hence the northeast trade wind. The explanation seems perfectly good, no fault can be found with it, and it has been universally accepted.

But now vary the locality and reason as follows: The air over 40° north latitude is much warmer than over 60° north latitude, therefore it rises and cold air flows in from 60° north to take its place, inasmuch too as the temperature fall from 60° to 40° north is much greater than that from 20° to 0°, the resulting flow is stronger, and this flow being turned by the earth's rotation into an east wind produces the still stronger east winds of the temperate latitudes. There seems no flaw in the reasoning, but the conclusion is in flat contradiction to the facts.

I can offer no explanation but put the difficulty to those who are prepared to think out the question for themselves without reference to or bias in favor of current explanations.

But while the cause of the westerly winds remains unknown, they do follow as a direct corollary to the easterly trades. This rests on the fundamental mechanical principle of the conservation of angular momentum, it was pointed out by Ferrel and deserves to be more generally recognized than it is.

Taking the earth's atmosphere as a system by itself, its angular momentum remains practically constant from year to year about the earth's axis; therefore the total couple due to all the forces acting upon it must be zero. The internal forces have no effect upon the system as a whole, and the only external force is that due to friction with the earth's surface; hence the total moment caused by friction between the air and earth, that is, the total moment caused by the friction due to wind, is zero. The friction acts in the opposite direction to the wind, and since the total moment is zero any easterly wind in one part must be compensated by a westerly wind elsewhere. Moreover, since the leverage is greater near the Equator because the distance from the earth's axis is greater the equatorial winds must either cover a smaller area or be of less strength. The area is not smaller, and hence the winds of temperate latitudes are the stronger. It follows also from this that since angular momentum is transmitted from the equatorial to the temperate regions there must also be an interchange of air, since the momentum can be carried in no other way. Hence the circulations in tropical and temperate parts are not independent of each other.

There seems to be no particular reason why the winds known as the "trades" should not be westerly and the winds of temperate latitudes easterly. Perhaps such a system is possible and might be stable if once established. It would explain the glaciation of northwestern Europe, for it would very greatly lower the temperature of that region, but it is not feasible as an explanation of the glacial epoch because it would raise the winter temperature of North America. The prevailing winds and the distribution of pressure are so closely connected that if one is known the other is also known. According to Buy-Ballot's law, a person standing with his back to the wind has, in the Northern Hemisphere, the higher barometric pressure on his right hand and the lower on his left. Now, latitude 30° lies to the north of the trade winds and to the south of the westerly winds, and accordingly the barometric pressure in the neighborhood of the 30° latitude circle—either north or south—is high. Again latitude 60° lies on the poleward side of the westerly winds and its barometric pressure is low. The question naturally arises, does the pressure distribution produce the wind or does the wind cause the pressure distribution, and the only answer yet available is that we do not know, though the latter conclusion is the more probable.

It has been stated that latitude 30° shows a high pressure. Broadly this is correct, but reference to a chart will show that patches of permanent high pressure appear on the oceans a little to the westward of the large continents, especially in the summer. The anticyclonic areas in these regions are so plainly marked that they can not be due to chance, and any satisfactory theory of the circulation will have to account for them.

Areas of high and low pressure have been explained in a simple way. Broadly it is true that over a large continent the pressure falls in summer and rises in the winter. In summer the air is warm, rarer, and therefore light; in winter cold, denser, and therefore heavy. This is the explanation given. In the Azores barometric maximum in July the air certainly is not cold. Over Europe in summer, if the summer is one of exceptional heat like that of 1911, the barometer is exceptionally high, not exceptionally low as the theory would require. Moreover, observations made in the higher strata of the atmosphere have shown beyond the possibility of dispute that as the ordinary changes of pressure pass over the weather chart it is the cyclone that shows the low temperature of the air as a whole and the anticyclone that shows the high temperature.

The temperature of the air must, however, play an important part in the circulation. It is certain that were there no temperature differences there would be no wind, and therefore it is important to consider the distribution of temperature in the atmosphere. The question is greatly complicated by the fact that air is compressible and that its temperature changes as its vol-

[1] It is quite usual to say "warm air rises and cold air flows in to takes its place"; but this expression disregards the important dynamic side of the phenomenon. It would be more exact to say always, that the surrounding denser air pushes the warmer, lighter air out of its way or upward because of the constantly acting force of gravity. The warmed, lighter air or gas does not rise of its own accord any more than does the balance pan carrying the lesser load.—C. A., Jr.

ume changes. Everyone knows this who uses a bicycle pump, for the end of the pump when the air is compressed becomes quite hot. In just the same way air that has come down from above is inevitably warmed, not because it has come down—that idea is a common mistake—but simply because it has come to a place where it is more squeezed and its volume is reduced. Conversely air that passes from a higher to a lower pressure is cooled because it has expanded. It makes no difference if it has risen 1,000 feet and thereby lost 1 inch of pressure, or if it has passed from the circumference to the center of a West Indian hurricane and similarly lost 1 inch of pressure. In both cases the loss of temperature due to expansion will be 5° F., but in the latter case the air will arrive at the center with the same temperature as the sea over which it has passed, as it will have been compensated for its loss at the expense of the sea. The rising air can obtain no compensation, as it is in contact only with other air subject to the same conditions as itself and in consequence it will have cooled nearly 5°. This adiabatic heating and cooling has very important effects upon the distribution of temperature in the atmosphere and upon the circulation, because it enables warmer air to lie under cooler. If two liquids of different densities are put in the same vessel, wine and water, for example, in a tumbler, it is impossible to make the lighter lie under the heavier, though the converse condition is easily obtained. Similarly if some water at a temperature of 40°F. be colored and placed in a glass with some clean water at some other temperature, the colored water can be placed at the bottom and the clean water, if it be inserted without mixing, will remain on the top; but the converse condition is impossible. This is because pure water at 40°F. is denser and heavier than water at any other temperature.

The same statement is true of air if instead of temperature in the usual sense we use the very convenient term suggested by Von Bezold, "potential temperature." "Potential temperature" is the temperature the air would have after its pressure had been altered to some standard pressure. Thus air of higher "potential temperature" can not lie under air of lower "potential temperature," The condition is unstable, like an egg standing upright on one end; but if the bottom air is only so much warmer than the upper that on rising it will be cooled below the temperature of the upper layer on reaching the same height, then the condition is stable like an egg lying on its side.

In what follows "potential temperature" will mean the temperature of dry air referred to the standard pressure of 300 mbar. (225 mm. or 8.86 inches of mercury); "warm" and "cold" will be used not as absolute terms but with reference to the usual temperature, just as we should call a day with a mean temperature of 50° F. cold if it happened in July, but very warm if it happened in January; and temperatures will be given in the centigrade absolute scale, on which 273°A. is the freezing point of water.

The change from actual to "potential temperatures" is troublesome when large changes of pressure are concerned, since logarithmic tables are required. The connection is

$$\log \frac{T}{T_0} = 0.29 \log \frac{P}{P_0}$$

where T_0 is the "potential temperature" and T the actual, P_0 the standard pressure and P the actual. But when the changes are small we have, by differentiating, $\partial T/T = 0.29\ \partial P/P$ where T and P are the existing temperature and pressure and ∂T and ∂P are small corresponding changes.

In recent years we have obtained fairly accurate knowledge of the temperature of the air up to 20 kilometers (12½ miles) over Europe and some knowledge of the conditions in tropical regions. The mean values are given in Table 1. The values for London are based on some 150 observations made during the years 1908–1914 in the neighborhood of London; they probably give correct means for those years within 1° or, at the outside, 2°C., and they agree within one or two degrees with the results obtained on the continent of Europe. The values for the Equator are more uncertain, observations there are too scanty as yet to give a mean that is reliable within some 5°C., but all the observations that have been made are consistent in this, namely, that extreme cold is met with at heights of 16 kilometers and over in the equatorial regions, and no doubt whatever remains that by far the lowest natural air temperature that has yet been measured is found high up in those regions.

The third column gives the temperature that air at any point would have if brought adiabatically under a pressure of 300 millibars. The temperatures would be different if some other standard of pressure were adopted, but the figures show two things: Where there is a large change of "potential temperature" with a small change of height the air is in a very stable condition and will strongly resist any vertical displacement. Secondly, if air in the process of circulation passes from A to B, then if the "potential temperature" at A is higher than at B, the air must lose heat (not necessarily temperature) in its passage, and conversely if the "potential temperature" is highest at B it must gain heat in its passage.

TABLE 1.—*Table of mean pressures and temperatures over London and the Equator.*

Height.	London.			Equator.		
	P.	*T.*	Pot. temp.	*P.*	*T.*	Pot. temp.
Km.	*Mbar.*	°*A.*	°*A.*	*Mbar.*	°*A.*	°*A.*
20	55	219	358	53	193?	319
19	64	219	343	63	193?	303
18	75	219	328	75	193?	288
17	87	219	314	90	193	274
16	102	219	300	107	195	263
15	119	219	287	128	198	254
14	139	219	274	152	203	247
13	163	219	262	178	211	246
12	190	219	250	209	219	244
11	223	220	240	244	227	242
10	260	222	232	283	235	239
9	303	227	227	327	243	237
8	352	233	222	376	251	235
7	407	241	230	430	258	232
6	468	248	218	491	265	230
5	537	255	215	558	272	227
4	612	262	212	632	279	224
3	697	268	209	713	285	222
2	791	273	206	803	290	218
1	897	278	202	903	295	214
0	1,013	282	198	1,013	300	210

There are two further points to be borne in mind with regard to the "potential temperatures." These temperatures are calculated on the assumption that the air is dry. This is not the case. The presence of vapor, however, does not matter until it begins to condense, but as soon as condensation commences latent heat is set free and the 0.29 in the formula giving the "potential temperature" ceases to be applicable. The value that replaces it depends upon the temperature.

The common rule given with regard to adiabatic heating and cooling is that rising air falls 10°C. in tempera-

ture for each kilometer that it rises and rises 10°C. for each kilometer that the air falls. This is true for short distances, but not for large. The rule is founded on the supposition that the special temperature conditions found in the air are such that the "potential temperature" is the same at each height. How widely this differs from the actual state of affairs is shown by the figures. The result is that for heights exceeding a few kilometers the allowance, 10°C. per kilometer, is too great, thus applying the formula $\log P/P_0 = 0.29 \log T/T_0$, and starting, from the ground level at London with a temperature of 282°A. the correct value at 10 kilometers is 190°A. and at 20 kilometers it is 120°A., instead of 182°A. and 82°A., which would be given by the 10° per kilometer rule.

It is perhaps hardly desirable to base any remarks on the general circulation on such localized observations as those collected in the table; but yet, on the other hand, all the observations on the temperature of the upper air that are available are more or less consistent with each other. It is only over Europe that the observations are sufficiently numerous to give the conditions in any detail, but the results obtained from North America, Australia, and elsewhere do not contradict any conclusions that can be drawn from the observations over Europe. Over Europe the effect of change of latitude is quite apparent, but no certain difference between east and west can be discovered. All available observations support the general rule that where the lower air strata are warm the upper are cold, so that while near the surface as one goes toward the Equator the temperatures rise, but above 12 kilometers or so the converse conditions are found and it is the polar regions that are warm and the equatorial regions that are cold.

The differences of pressure at the same level are a striking point in Table 1. If two columns of air of different temperatures but the same pressure at the bottom, could stand side by side the greatest difference of pressure between them would be at the height of the homogeneous atmosphere, i. e., at a height of from 8 to 9 kilometers. Thus in Table 1 from 5 to 11 kilometers, differences of pressure of over 20 millibars are shown between the Equator and latitude 52° N. It is no great wonder, therefore, that the strongest winds should be found at these heights. At 18 kilometers the pressures are found to be the same. These pressures are of course calculated from the surface pressure and the observed temperatures, and we can not be sufficiently certain of the mean temperatures over the Equator to be sure that the pressures given in Table 1 are correct; but it is certain that above 10 kilometers the differences rapidly decrease and almost certain that somewhere between 15 and 20 kilometers there is a level where the difference is nothing.

It has been pointed out already that, owing to the earth's rotation, a wind does not blow direct from the high to the low pressure, indeed it is obvious that if such were the case the low pressure area would very rapidly be filled up by the air entering it, but it blows at right angles to the pressure gradient. Thus the decreasing value of the pressure at the cirrus level, as the latitude increases, will account for the westerly winds at that level. Also since the journey from the Equator to latitude 50° is a long one, there is ample time for a wind starting as a south wind to be turned into a west wind.

The prevailing winds at that level in temperate latitudes are known to have a westerly component, but it is equally certain that westerly winds are not always blowing, at least over Europe, for many balloons have been sent up and have fallen without encountering any drift from the west. It may be of interest to state here that over Europe the "center" of the falling place of balloons that reach from 12 to 20 kilometers height, is between east-southeast and southeast of the starting point, thus showing that over Europe there is a drift from the north as well as from the west. This is probably local, but since the rate of ascent of a balloon is much the same at all heights the mean drift must refer to height and not to the mass of the air. If, therefore, the drift in the lower strata is from the south, the balloons may still fall to the south without proving that the drift of the mass of the atmosphere is from the north, for half of [the mass of] the whole atmosphere lies below 6 kilometers and nearly three quarters lies below 10 kilometers.

If we average the temperatures (in Table 1) with regard to mass we find 250°A. for the mean in the neighborhood of London and 264°A. for the Equator. Taking the atmosphere as a whole it is as a matter of course continually losing heat by radiation into space, it is also being warmed by solar radiation, direct and indirect, and by contact with the earth or sea already heated by the sun. Since its temperature remains unchanged to any appreciable amount from year to year it must lose by radiation just as much heat as it receives. We may assume, probably without error, that the amount of heat the atmosphere radiates out into space varies as the fourth power of the absolute temperature in accordance with Stefan's law and if we take 255°A. as the mean temperature that is maintained under the average solar radiation, we can calculate what the mean should be under any other amount of solar radiation. In Hann's well-known book the solar radiation at the Equator is given as 350°A. in comparison with 240°A. in latitude 50°. Were there no circulation and were the temperature at each place dependent only on the ratio between the values of the radiation, the ratio of the temperatures between the Equator and latitude 50° should be the fourth root of 240/350 which is very nearly 91:100, and the ratio between 250 and 264 is a little under 95:100. The temperature difference is therefore less than the difference in radiation would lead us to expect and the equalization must be produced by the circulation. If the figures were sufficiently trustworthy one might get an idea of the interchange of air, but not only is the 264°A. subject to a large casual error, but also the 250°A. for Europe, though reliable, only refers to a small part of the latitude circle.

Knowing with fair accuracy the value of the solar constant, the amount of heat that the whole atmosphere loses per day can be estimated with some accuracy. The doubtful point is the amount of solar heat that is reflected back without being directly or indirectly absorbed by the air. The result is that the fall of temperature per day on account of "out" radiation alone is from two to three degrees. This is the average value; it would be more near the Equator, less near the pole.

The temperatures that are given in Table 1 are very interesting but they are difficult to explain. Before observations were set on foot no one would have expected that the lowest natural temperature that mankind has measured would be found at some 10 miles height over the Equator, yet so it is. The actual mean value, 193°A. (−180°C., or −112°F.), may be doubtful, but the value is certainly far below that found at the same height in temperate latitudes. The highest mean [upper air] temperature is given by Petrograd (Pavlovsk), the station of highest latitude from which regular observations are obtainable. It seems to me that there is one and only one feasible explanation. The low temperature

must be due to the general ascent of the air, and it must occur in spite of and not in obedience to the radiative conditions. Radiant energy is most intense at the Equator, both direct and indirect. The earth and lower layers of air are warmer and the radiation they send upward is more intense. It is utterly impossible that this can be checked by a veil of cirrus or other cloud, for if checked it can only be by being absorbed or reflected; if reflected it must raise the lower temperature still more; if absorbed it must raise the temperature of the absorbing body until the latter gets so hot that it radiates outward as much heat as it is receiving from below.[2] Thus inevitably air at 16 kilometers over the Equator must, so far as radiation only is concerned, with intense solar radiation coming from above and hot damp radiating layers below, be warmer than air at the same level in the winter over the plains of northern Russia, with no appreciable solar radiation from above and a surface of snow below having a temperature not much above the freezing point of mercury. Yet the air high up over the snow-covered plain is about 30°C. (54°F.) warmer than that over the rank steaming jungle of the Tropics.

The fact can be explained if we suppose a steady though slow rise of air in the Tropics and a corresponding fall in regions nearer the poles. There is overwhelming evidence to show that away from the earth's surface the local distribution of temperature is governed far more by the distribution of pressure, which alters the temperature directly and also by inducing vertical motion, than by radiation. This evidence will be given later. The question of the radiation of the atmosphere is a very difficult one. It has been shown that the atmosphere, taken as a whole, at a temperature of about 255°A., would lose by "out" radiation about 2.5°C. per day. It may be inferred that if the atmosphere as a whole had a temperature of 280°A., say, it would lose $2.5° \times (280/255)^4$ or nearly 4°C. per day, and if a temperature of 230°A., it would lose about 1.3° per day. But it is not safe to infer that a small mass of air at 280°A. placed anywhere loses at the rate of 4°C. per day (of course we are taking no account now of the energy that is absorbed) because the absorbing and radiating power of air depends very greatly on the amount of water vapor and carbonic acid present. Warm air in general, even in places like the Sahara, has plenty of water vapor, cold air can contain very little, hence warm air possesses a power of radiation which cold air does not possess and the question becomes very complicated. Added to this there is the radiation from clouds, of which we know very little. A heavy rainfall puts an enormous amount of heat into the atmosphere; this heat does not seem to alter the temperature much and it is hard to see what becomes of it unless it be dissipated by radiation from the top of the storm clouds that cover the rainy area.

One point, however, is fairly clear. The mutual radiation between different parts of the atmosphere must tend to equality of temperature throughout. Air, like all other substances, can absorb just those wave-lengths which it can radiate, both processes for dry air at any rate are slow, but perhaps all air possesses sufficient moisture to render radiation efficient. We know that the atmosphere is able to absorb a large proportion of the solar rays.

The air is actually warmest at the bottom and there are two separate ways in which this may be brought about. Both the temperatures of the sea and of the ground are higher than that of the air lying just above them, at least this rule holds for the warm parts of the earth and for the summers of temperate latitudes. This higher temperature is produced by the solar radiation that gets through the atmosphere and reaches the ground and thus affords to the air a source of heat at the bottom. The result must be a temperature gradient from below upward, but it is not easy to estimate what the magnitude of this gradient ought to be. The other possible explanation will be discussed later.

The actual figures in the columns (Table 1) showing "potential temperatures" are of no importance because they depend on the standard pressure chosen, which is quite arbitrary. The difference between two "potential temperatures" is significant so long as we do not depart too far from the height corresponding to the standard pressure, in this case about 9 kilometers. If the air at any point were in neutral equilibrium, the "potential temperature" would not change with the height. The fact that the "potential temperature" everywhere increases with the height proves the stability of the atmosphere. Equal "potential temperatures" would correspond to an ocean of water, pure or of uniform salinity and of equal temperature throughout. Ascending and descending currents could be set up with ease in such an ocean. The actual conditions correspond to an ocean having layers of different liquids, the heavy liquids being at the bottom, the light at the top, and the different density of each layer is shown roughly by the reciprocal of the "potential temperature." Such an ocean would permit of horizontal currents being set up without much trouble, but it would resist vertical circulation.

The "potential temperatures" of Table 1 are calculated on the assumption that we are dealing with air in which water is not being condensed. For parts in which rain is being formed the 0.29 of the formula is too high and the "potential temperatures" would be nearly equal for successive kilometers. In such parts, therefore, the stability need not be large. But ascending air in one place is of necessity accompanied by descending air somewhere else and for descending air the "potential temperatures" of the table are correct. Also the parts in which rain at any moment is being formed are, in comparison with the whole atmosphere, of very limited extent, hence the average condition is one of considerable stability and vertical motion will be strongly resisted.

A second point about the "potential temperatures" is this. It has been already pointed out. If air passes from one place A to another B, and the "potential temperature" of B is above that of A, then on the whole during the passage the air must receive more heat than it loses. For air that does not touch the ground the sources of heat are only two, viz, heat set free by condensing water vapor and heat received by radiation from bodies warmer than itself. The converse holds, but the loss of heat can only be by radiation to colder bodies or to space.

It follows that all descending air is losing heat. This is readily explained, for descending air becomes warmer than its surroundings since the average temperature gradient is not equal to the adiabatic gradient, and therefore it loses heat by radiation to the neighboring air.

Ascending air is gaining heat. The explanation is similar to, but the converse of, that given above, but in addition in the lower strata ascending air produces rain and the air receives heat from the latent heat of

[2] Compare in this connection the exposition by *W. J. Humphreys* in Bulletin of Mount Weather Observatory, 1911, v. 4, pt. 3, p. 130-131.—C. A., jr.

condensation. This fully explains the greater rise of "potential temperature" in the lower strata.

Air passing horizontally near the surface is gaining heat when going toward the Equator. This is natural enough, for a north wind is naturally cold and is being warmed by its surroundings. The converse also holds.

The most interesting case is that of the horizontal passage of air north and south at great heights. The temperatures above 17 kilometers at the Equator must be accepted with great reservation, since observations are very scarce, but from about 12 to 17 kilometers the equatorial potential temperatures are certainly much below the others. The pressures are greater also, so that the flow of air should be toward the north. If the flow is toward the north the air is gaining heat and it seems to me that from its situation it ought to be doing so. It is very cold and therefore is not itself radiating much either upward or downward, and it has passing through it outward the whole radiant energy which is being sent outward by the earth and by the four-fifths of the atmosphere which lie below it, and much of which is at a far higher temperature. It is likely to be a long time before any direct observations can show which way the drift is, for a very slow motion will suffice to explain the low actual temperatures over the Equator. The general motion is from the west, and it is a question whether on the balance over the whole zone the direction is a few degrees north or a few degrees south of west. The ascending current over the Equator is certainly slow, a hundred feet a day, perhaps, or something of that sort; otherwise the temperature gradient would be steeper; and the air carried up by so feeble a draft could readily escape north and south without detection, even if we had as precise observations of the upper winds as we have of the surface winds.

Reverting to the actual temperatures, it is noteworthy how similar the temperature gradient is in the two localities. It begins at about 5°C. per km., then after the cloud level, excluding cirrus, is passed it increases to 7° or 8° per km., up to the point at which it stops altogether. This point is higher the lower the latitude. Observations from all parts of the world show the same tendency, except that where the surface temperature is very low the gradient in the lower strata is absent or reversed.

It seems to me likely that this special form of gradient is a sort of compromise between two opposite tendencies. It is obvious that if the air could be thoroughly mixed up, the adiabatic gradient would prevail throughout, for the mixing will make equal potential temperatures, just as stirring the water in a bath makes a uniform temperature. Now, the winds, however they may be caused, must do a certain amount of mixing and hence must raise the bottom temperature and lower the top; and unless there were something else to reverse the result the process would go on until the gradient were adiabatic. But radiation checks the result, I believe, for in my opinion the tendency of radiation is toward a uniform temperature or to a small gradient. The argument seems clear that the winds alone must make an adiabatic gradient, since they do not do so something must interfere with the process and that something can be nothing else save radiation. It is significant, too, that observation shows that the wind falls off rapidly at or about the point where the temperature gradient ceases.

The statement previously made that upper-air temperatures depend on the pressure distribution rather than on radiation is based on the following facts. So many observations have been made over Europe, ranging from Pavia in the south to Petrograd in the north and from Ireland in the west to Russia in the east, that we have quite a good knowledge of the conditions both in summer and winter and in times of cyclonic and of anticyclonic weather. Over the British Isles solar radiation in summer is about three times as great as in winter and the temperature of the air up to 10 kilometers is in general 12°C. (21°F.) warmer. Nothwithstanding this, for the purpose of knowing the most likely temperature of the upper air, it is more important to know the height of the barometer than to know the time of the year, for after the first kilometer or two is passed the air in a well-marked cyclone will be colder in summer at from 3 to 7 kilometers than it is at the same height in winter in anticyclonic weather; and above 12 kilometers the converse will hold. The same rule holds for Europe generally, but cyclonic conditions there are much less frequent. Moreover, it is not the pressure at sea level that is important, but the pressure at about 8 or 9 kilometers. The temperatures both above and below follow the variations of pressure at 9 kilometers with the utmost precision, and if a chart showing pressures at 9 kilometers could be given it would be easier to draw a chart of temperatures at 5 or, to a less extent, at 15 kilometers than it is to draw a chart of wind forces and directions from isobars on an ordinary chart. The pressure at about that height seems to dominate all the other elements.

FORECASTING THUNDERSTORMS.[1]

By GABRIEL GUILBERT.

[Dated Aug. 3, 1912.]

1. Wireless telegraph installations are known to possess the curious property of recording [indicating] the electrical manifestations produced in their neighborhood and even at very great distances.

Thus, on March 4, 1912, a formidable thunderstorm accompanied by trombes descended upon Calvados [Department Caen] at about 19^h and a meteorologist of the Lyon observatory, M. Flajolet, simultaneously observed his wireless apparatus to record powerful distant phenomena.

It was but a step from this observation to the thought that it would be possible to announce for a given point, the approach of a distant thunderstorm indicated by the wireless outfit, and physicists such as M. Turpain of Poitiers have attempted these predictions.

So far it has not been possible, unfortunately, to forecast the direction of these distant thunderstorms. Thus, in the case of the squall of March 4, 1912, the apparatus at Lyon did indeed record the existence of a storm, but could not indicate whether or no the storm was approaching the observatory. As a matter of fact it was traveling toward the NNE. part of France and was moving away from Lyon. The wireless telegraph remained and will remain mute, powerless, on this essential point as well as on the speed of the storm.

Certain squally clouds are indeed either very slow moving or very rapid; they may move at the rate of 20 or of 100 km.-hr.; wireless telegraphy knows nothing as to that and can not know anything.

On the other hand, certain meteorologists believe that they can notice that the wireless apparatus also reacts to phenomena quite other than thunderstorms; there is thus

[1] *Translated from* Association Française pour l'avancement des sciences, Compte rendu, 41me sess., Nimes, 1912. (Paris, 1913), p. 296-304.—C. A., jr

some uncertainty as to the significance of the indications of the apparatus. Finally, the wireless can not announce the passage of thundersqualls *not yet in existence*, e. g. 24 hours before they develop, or even of thunderstorms raging in some undetermined direction, a direction all the more indeterminate because several thunderstorm centers (centres orageux) may exist simultaneously and either to the north or to the south of the station at some unknown distance.

2. So it is that if one wishes to predict the squall not merely some hours in advance, but even in the evening for the morrow, it is necessary to resort to the rational study of isobaric charts, of barometric depressions, of squall lines or zones,[2] and to supplement these by a methodical examination of the clouds.

3. Thus always, whatever method one may choose, the forecasting of thunderstorms for any given locality will always be very deceptive. Failures will be frequent for the simple reason that the thunderstorm takes place in clouds of limited extent which therefore most frequently visit but a small number of points in the region under consideration. On the other hand the failures will be very rare if one admits that the passage of a single thunderstorm at a single place in the designated region is a sufficient justification for the forecast "Thunderstorms."

4. The majority of meteorologists group thunderstorms into two principal classes: The thunderstorms accompanying a depression, and local thunderstorms; or even into winter thunderstorms and heat thunderstorms. To the writer these distinctions seem but little justified and even arbitrary. Thunderstorms that accompany, in effect, the depressions of winter or of summer are sometimes very local while in other cases thunderstorms pursue very long courses without any accompanying sensible depression. Therefore this classification is defective, as for the so-called heat thunderstorms, or those whose principal cause is supposed to be a very high temperature, their relation to the temperature is not at all proved.

[**A**] The warmest days often fail to bring about any electric manifestation at all, and the warmest months are those most free from thunderstorms, as we have shown.[3] The name "local thunderstorm" would therefore appear to be more correct. Yet another designation is current "the thundersquall" (l'orage de grain). In its relations to barometric depressions this is a cyclonic thunderstorm in winter, a depressionary thunderstorm (orage dépressionaire) in summer, and never a heat thunderstorm.

5. If the thunderstorm produced only lightning or thunder, it would be of only relative importance, but it may bring along a whole series of redoubtable phenomena. Its prediction calls out the possibility of wind blasts as sudden as they are violent, torrential rains and floods, disastrous hail falls, whirlwinds or tornadoes of frightful force. These catastrophes are possible at any time of year. Hail or whirlwinds may occur whatever the temperature. No doubt one notices hail particularly during the summer because it then causes the greatest damage to vegetation, but hail falls at all seasons of the year.

The forecasting of thunderstorms implies the forecasting of all these phenomena, which are the possible consequences of magnetic manifestations. As a matter of fact, however, these accessory phenomena are rare. The violence of the wind is not often dangerous. Among 10 thunderstorms there is scarcely one that brings a fall of hail; among a thousand there is perhaps one whirlwind. To be sure, these ratios vary according to the regions and even according to the observatories. They would be considerably heightened if one compared the number of hail falls or the development of whirlwinds, not with the number of zenithal thunderstorms but with the number of days of thunderstorms recorded in a more or less extensive region such as a "Département." Then one would find hail falls once in 5 and whirlwinds once in 100 cases.

6. We are not here concerned with statistics, however, for at the present time it is not possible to forecast either hail falls or tornadoes. We are simply able to predict the thunderstorm, or rather the passage of squally clouds liable to be the seat, at one point or another, of electric manifestations and also the accessory phenomena such as hail, wind squalls, or tornadoes. The thunderstorm brings them all in its train; it may produce them simultaneously or fail to give any of them expression. There is, therefore, complete uncertainty as to the atmospheric disturbances that may accompany the thunderstorm.

7. Some secondary phenomena are always regularly observed, without exception, in thunderstorms.

In the first place there is a change in the wind, both as to direction and to velocity. For example, the wind changes from S. to W., returning to SW., and from being weak it becomes strong, only to weaken anew. The barometer is usually low, rises brusquely, soon to become stationary, then falls again. The temperature drops notably, while the hygrometric condition rises. As is well known, these characteristic variations have been extensively studied by Durand-Gréville, author of "Loi des grains" (Law of Squalls). The thunderstorm is no longer the principal phenomenon; it is the accessory and the consequence of a squall. It is the squall that determines the thunderstorm and, even in the absence of the latter, produces the variations in wind, pressure, temperature, atmospheric humidity, cloudiness.

Even though these phenomena affect diverse forms and develop successively, the squall nevertheless exists. M. Durand-Gréville has here established, from a very large number of observations, an undoubted ensemble of features which in my opinion permit the differentiation of the principal barometric depression, of the secondary depression, and of the *squall*, whose existence is undeniable. From the present point of view, however, i. e., the forecasting of the thunderstorm, the study of the squall is secondary. [**B**] According to Durand-Gréville himself, the squall (grain) is not the actual cause; it is not able to produce the thunderstorm except under the conditions where it meets with cumulus having very lofty summits. So that lacking this cumulus the squalls or the squall zones can not produce the thunderstorm. Therefore the atmospheric phenomena constituting the squall (grain) can not serve to forecast nonexistant thunderstorms, and all the less to forecast thunderstorms for the next day. Furthermore, the squall, like all cyclones and depressions, may have but an ephemeral existence. It may develop or it may diminish and disappear after having traversed a more or less extensive path. It would be venturesome to conclude, from its presence at one point, that a squall would pass over some other region after a given time, and all the more so since its speed of translation is unknown.

Again, the thunderstorm is not bound solely to the squall line or the squall zone. It may develop even at the center of the cyclonic whirl; each thunderstorm cloud may be the center of a vortical motion, and the passage

[2] These terms were defined and illustrated in this REVIEW, June, 1909, 37: 237-39.—C. A., jr.

[3] Not the case for the United States of America. See *Alexander* in the REVIEW, July, 1915, 43: 326-340; and *Lyman* in this REVIEW, December, 1915.—C. A., jr.

of every cyclone over any point produces exactly the same phenomena that one would exclusively attribute to a squall. With or without a thunderstorm one would note a sudden and sometimes overwhelming increase in the wind velocity and its direction; the sudden rise in the barometer; the equally sudden fall in temperature; the corresponding rise in the hygrometric state and in the cloudiness.

All these phenomena may be observed, with appropriately decreased intensity, out to a considerable distance from the cyclonic center, without it being necessary to call in a squall line. One must therefore conclude that the *cyclone* of vast extent, the *depression* or small-scale cyclone, and the *squall* (grain) or yet more limited atmospheric whirl, and even the imperfect *vortical wave* are distinct phenomena identical in nature and therefore able to produce identical perturbations.

8. Thus M. Durand-Gréville has very truly stated that a thunderstorm can not develop unless, previous to any barometric condition, there exist a *great cumulus with very lofty summits*. I am wholly of his opinion. The presence not of cumulus but of *cirro-nimbus* is the essential condition for the thunderstorm, and it is therefore quite logical to make the forecasting of thunderstorm clouds the fundamental basis of thunderstorm forecasting.

9. If there is one fact that ought to attract the attention of meteorologists, that is the similitude of cloud forms at all seasons of the year. Cirrus, cirro-cumulus, alto-cumulus, and cumulus present the same aspects on the most rigorous winter days as on the warmest days of summer. A priori, a similar observation, seems to demonstrate that the formation of clouds is independent of the air temperature at the earth's surface. Clouds would accordingly develop in a cold atmosphere, so cold, in fact, that in my opinion they would never produce rain, but always snow. Furthermore, the thunderstorm clouds, which obey the same law and present characteristic forms at all seasons, are of the upper clouds, composed of ice crystals or of snow, and which we designate for that reason *cirro-nimbus*.

This cirro-nimbus always forms a part of the company of clouds that we call the "cloud succession" (succession nuageuse) and which comprises the cirrus, cirro-cumulus, cirro-stratus, alto-cumulus, and finally the cirro-numbus. Lacking the presence of these latter clouds, it must be stated as a principle that any thunderstorm is impossible, that it will never burst forth in the cirro-stratus or in the cumulus whatever be their extent. Even more, whatever be the barometric depression, the squall zone, the visible clouds, the temperature, if cirro-nimbus can not exist the thunderstorm is impossible.

On the other hand, if the "cloud succession" calls for cirro-nimbus, all the thunderstorm phenomena become possible, although not assured, and this holds whatever may be the atmospheric situation.

It results from this postulate, which I published in 1886 [4] and which is confirmed by each day's experience, that the cause of the thunderstorm is to be sought solely in the structure, the composition or the physical changes in that strange cloud, and that the prevision of the thunderstorm should be united with the prevision of the arrival or passage of the cirro-nimbus.

This prevision is all the more possible since the thunderstorm cloud is the *last* in the "cloud succession." It is always preceded by the cirrus, the cirro-cumulus, the alto-cumulus. Thus it does not arrive unheralded, does not spring into being without any notice in advance, it does not burst forth in the bosom of a cumulus due to high temperature nor in an atmosphere *appropriately prepared*.

One of the most convincing proofs of this statement is to be found in the observation of the speed of the first clouds of the "cloud succession." If the cirrus is driven at great velocity, the cirro-nimbus which should follow it will also have a rapid movement; if the preliminary cirrus moves slowly, the thunderstorm clouds in their turn advance more slowly. This relation between the velocities of successive cloud classes, and which endures a number of days, excludes all idea of a local formation.

10. As the plan of this study does not permit of reviewing all the cases of agreement or disagreement between different clouds and the depressions, we shall confine ourselves to the cirro-nimbus in its seasonal relations to the thunderstorm.

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11. In general, showers (averse) or rains of short duration, which are often abundant and sometimes torrential, are due to the passage of the cirro-nimbus. Therefore all forecasts of showers imply the forecast of thunderstorm phenomena; therefore one should predict, not "showers," but thunderstorm showers. [C] Also, therefore, the forecast of thunderstorm showers is synonymous with the forecast of squalls. In fact, in the mariner's language the squall is nothing more than the passage across the zenith of a cloud with showers in a clear sky. This cloud unchains violent wind gusts, obliging the mariner to reef his sails, and even to furl them. When the shower is over, the weather changes to fine again and the wind, which is then almost always between SW. and NW. or N., diminishes its force until the return of another cirro-cumulus provokes another squall, i. e., a renewed gust accompanied by sensible changes in wind direction and often barometric oscillations also.

Thus all showers are due to squalls, and it is in these squalls that occur most of the winter thunderstorms, which generally consist of a few isolated peals of thunder.

We propose as a thesis, *that all winter storms are* accompanied by thunderstorms. Thus the stronger the depression during the cold season (November to March) the better the chance of success for the thunderstorm forecast. These cyclonic thunderstorms arise most frequently where the wind changes from S. to W., or from SW. to NW. They chiefly visit the regions neighboring the sea. [Conditions of western Europe.]

12. March, which closes the cold season, is the month par excellence of the hail shower (giboulée). These showers, with their generous hail falls, are often thunderstormy. They belong to the cyclonic régime: The deeper the depression, the more numerous are the thunderstorms within the dangerous semicircle of the cyclone, and in the rear of the center.

13. From the thunderstorm point of view, the summer may be said to begin with April and to close with the autumnal equinox.

While during the winter the thunderstorm shower rarely appears other than in the rear of the depressions, the summer thunderstorm may occuppy even the center of the cyclonic whirl. In winter the wind and the thunderstorm follow the same direction, within a few degrees; but in summer the thunderstorm moves against the wind or makes more or less of an angle with the latter. In winter the thunderstorm always accompanies or follows

[4] Annuaire de la Société météorologique de France, avril, 1886.

very closely after a violent cyclone; but in summer the weakest depression may produce a thunderstorm.

* * * * *

14. It is somewhat easy to forecast thunderstorms when the summer depressions appear over the southern regions of France; but it is much more difficult when a depression, over the Gulf of Gascony for example, suddenly disappears.

Although the pressure may be higher to the north, e. g., 770 mm. at Dunkirk, 765 at Mans, 760 at Biarritz, there is no cyclonic center. Under such circumstances the "cloud succession" alone furnishes a basis for a forecast. In fact, it is scarcely admissible that a depression should appear without a cloud accompaniment. If, in spite of the barometric rise, the cirrus, cirro-cumulus, alto-cumulus appear in regular succession, in the same direction from southerly points northward, and in spite of easterly winds, then it is infinitely probable that the cirro-nimbus will follow them in its turn. Therefore, even after the depression has disappeared, even in the case of a barometric rise (slight to be sure), even in the absence of the "squall zone" or of V-shaped isobars, yet the existence of a "cloud succession" would suffice to foretell the thunderstorm. Thus came in the too-famous thunderstorms of July 29, 1892, June 6, 1904, July 4, 1905, June 30, 1908, etc., all of which were characterized by an extraordinary violence in spite of the absence of sensible depressions and even in the face of high pressures with rising pressures. In fact these examples justify one in setting up the thesis that *the intensity of electric phenomena increases with the rise of the pressure.* A thunderstorm occurring in the summer with the barometer about 765 mm. will cause more ravages by rain, hail, or lightning than if the pressure had fallen to 755 or thereabouts.

15. [**D**] There is no occasion to introduce here hypothetical phenomena which, moreover, do not demonstrate anything: Such as the rapid descent of a sheet of air to the ground, or the precipitation of cirrus upon subjacent cumulus. The most attentive observation does not reveal any disturbance of this nature. The cooling frequently observed after the thunderstorm is often due to the change in the direction of the wind, a cyclonic phenomenon, and also to the sudden melting of a prodigious quantity of ice or snow crystals. The consideration of the vortical character of the squall offers a very simple explanation of the barometric variations and the fall in temperature as well as of the increase in cloudiness.

16. While the depressions of Gascony and the summer "cloud succession" of the south of France are the greatest sources of thunderstorms for almost the whole of France, there is yet another very remarkable thunderstorm formation, viz, the arrival of Saharan depressions upon the coast of Provence. As soon as a cyclonic center persists in that region, with cirrus and then cirro-cumulus from the SE. changing to E., we have to expect thunderstorms between the SE. and NE. throughout France accompanying winds from the east as well as from the west.[5]

* * * * *

17. To sum up, all thunderstorm forecasts should be based upon a simultaneous study of the barometric situation and of the cloud successions. The study of the isobaric map should lead to a forecast of the future pressure distribution, of the formation of depressions, and of squall zones for the next day. The study of the cloud succession ought to show whether or not *cirro-nimbus* should develop and also whether or not it will coincide with the depression centers on the morrow. The clouds indicate, better than do the depressions, the direction and speed of tomorrow's expected thunderstorm. On the day itself a station can determine this speed and direction only shortly before the arrival of the storm. [**E**] The consideration of the squall zone is insufficient, for its trajectory is indeterminant while the thunderstorm pursues a straight-line course, or at most a curve of very large radius, which neither the topography nor tidal movements nor even the manifold directions of the surface winds can deflect. Hail-falls and paths of destruction by tornadoes always make straight lines, which confirms these conclusions based on direct observations. Successive thunderstorms, even though each occupy the center of a slightly whirling movement having variable winds in all directions and with the lower clouds from an opposite direction, nevertheless advance in the direction indicated 24 to 48 hours previously by the upper clouds.

The thunderstorm, the *cirro-nimbus*, thus exist only in the higher levels, so that it is not possible to have any means of influencing either their direction or their effect. And yet the thunderstorm is of very limited duration, at most it may last 24 hours, generally a few hours suffice to exhaust it.

Perhaps the progressive descent of the upper clouds is a cause of its destruction. One has thus observed extensive thunderstorm clouds moving from S. to N. with lightning and thunder, dissipating, dissolving, even disappearing, with more or less observable delay, under the action of very dry winds from the N. or NE. The thunderstorm cloud subsists in the southerly current, but very probably experiences an evaporation as it attains the northerly current. The thunderstorm ceases while the thunderstorm cloud steadily fades away.

COMMENTS BY DURAND-GRÉVILLE.

[The foregoing paper by M. Guilbert called out the following comments by M. Durand-Gréville,[1] whose studies in thunderstorms, squalls, and hail have already been noticed here (1909, **37**: 237–239). References are to the passages marked by corresponding letters in M. Guilbert's paper.—C. A., jr.]

In a memoire "On the forecasting of thunderstorms," published in this volume, M. Guilbert puts forward his own ideas and rejects some of mine, which he has a perfect right to do; but he states my views in such a summary and fragmentary manner that the unwarned reader might not understand exactly what I hold in this connection. The present note designs less to present a fundamental discussion of our colleague's theory than to present our precise opinion concerning certain of the points that he discusses.

1. *Guilbert* says (**A**, p. 557):

> The warmest days often fail to bring about any electric manifestation at all, and the warmest months are those most free from thunderstorms, as we have shown. The name "local thunderstorm" would appear to be more correct (than that of heat thunderstorm).

Durand-Gréville.—The thunderstorm is an electric disruptive discharge between the negative electricity of the earth's surface and the positive electricity of the cirrus region. The discharge does not take place unless a sufficient communication is established between the two levels. This communication is realized every time

[5] The direction of the thunderstorm cloud, cirro-nimbus, is often independent of the trajectory of the cyclonic centers and of the squalls, therefore also independent of the surface winds.—AUTHOR.

[1] Mise au point de quelques objections à notre théorie des grains et de la grêle. Assoc. franc. pour l'avance. d. sci., Compte rendu, 41me sess., Nimes, 1912, Notes et Mémoires (Paris, 1913), p. 286–291.

when, over a limited region of the surface which is being strongly heated by the sun and in an atmosphere sufficiently warm and humid, there develops a cumulus with very lofty summit, which serves as the intermediary communication. Within the tropics, and chiefly over islands, ascending currents of warm, humid air develop every day in the warmest of the afternoon hours, hours when the thunderstorm bursts with regularity. Heat alone would not suffice to produce cumulus; for this reason thunderstorms are very rare in the very dry and very warm regions of the globe, even under the tropics. Thunderstorms that develop and remain in the same place deserve the name of "local thunderstorms." One should call them "heat and humidity thunderstorms" in order to bring out the double cause for the formation of cumulus. But since our senses perceive humidity much less readily than heat, particularly when the air is warm, one has fallen into the habit of calling them simply "heat thunderstorms."

FIG. 1.—Arrangement of winds in a squall, after Durand-Gréville. (Vertical section.)

Heat thunderstorms occur in temperate regions also but much more rarely because there is much less chance of there realizing the conditions favorable for developing the extremely high cumulus. Nevertheless, the thunderstorm may readily develop in temperate regions if the summits of the less lofty cumulus (e. g. 5 to 6 km.) are put in communication with the higher levels by means of the descending sheet of air of the squall zone. [See fig. 1, *A*.] The thunder squall endures so long as the squall wind completes the communication between the cirrus region and the ground.

In passing may be here mentioned the extremely rare cloudless thunder squall with its tempest of dust. Clear cut examples of this storm have been found only in Australia, and it would seem to specially favor the production of ball lightning.

After these remarks it remains to point out that in our climates the immense majority of thunderstorms are those of the squall zone. To produce a thunderstorm there must first of all be a local cause: the presence of large clouds previously formed in a warm, humid atmosphere by ascending currents. But if they are to be extremely high these cumuli may exist throughout the whole day without bringing on the slightest thunderstorm. In order to produce the latter there must be a dynamic cause, viz, the passage of a squall zone (generally coming from a great distance) which establishes the communication between the two oppositely charged layers. Squall zones may exist at any hour of the day, ready to further the production of the thunderstorm. But one can see that their action would be more effective in the hours favorable to the building of great cumuli, i. e., during the warmest hours of the day.

Other things being equal, thunderstorms are most numerous and violent during the warmest months of the year. This fact is demonstrated by the thunderstorm statistics for all countries where there are a sufficient number of years of observations. If one compiles the data for a single year in a single country, even though it be as large as France, one might reach other apparent conclusions, which would disappear, perhaps, upon making a more profound examination.

For example, in M. Dongier's memoir "Les orages en 1907" we find that the number of thunderstorms observed from November to March has its minimum in January (115), its maximum in December (713); during the other seven months it varies from 2,166 (October) to 5,652 (May), with 4,489, 4,467, and 4,105 for June, July, and August. This result does greatly depart from the mean of the statistics. Evidently the number corresponding to the cold months is much smaller than that for the warm months. One may, however, ask whether the predominance of May is real. It is easy to find the answer to the question. At the beginning of his study M. Dongier observes that, throughout the greater part of France, the number of observers is still too small to furnish a guaranty that thunderstorms have not slipped unnoted through the meshes of the réseau. He does better, he mentions the names of 23 Départements where the guaranty of exactitude is sufficient. I have taken the statistics for the 23 Départments and the result was, as we anticipated, that August secured the preponderance to the detriment of May. Each may make the verification for himself.

Certain regions, the mountainous ones, form an exception to the rule. Corsica, for example, is richer in thunderstorms in winter than in summer. The explanation of the fact would be easy: the heating of the mountain flanks favoring the formation of cumulus; but this would carry us too far. Here it suffices to observe that, in our country as elsewhere, the winter thunderstorms are to be counted by hundreds, while the summer thunderstorms are in the thousands.

2. *Guilbert* says (**B**, p. 557):

According to M. Durand-Gréville himself, in the absence of cumulus, the squall zones would not be able to produce the thunderstorm. Therefore the squall can not serve for forecasting nonexistant thunderstorms, and far less for predicting the thunderstorms of to-morrow. Besides, the squall can not have more than an ephemeral existence. It would be rash to conclude that because present at one point it will pass over some other region after a determined delay, and all the more so because its speed is not known.

Durand-Gréville.—Observation proves that the squall zone by itself (save the almost unique Australian case) can not produce the thunderstorm. Observation also shows no less clearly that a large cumulus, or even a cumulo-nimbus (i. e., a cumulus draped with a mushroom head of cirrus, otherwise the "cirro-nimbus" of M. Guilbert) [2]—disregarding the, for us, very rare case where its summit is lofty enough to almost attain the region of the upper cirrus—will remain inert during many hours and not become the seat of disruptive electric manifestations until the precise moment when the descending sheet of a squall zone, which likewise produces at the same instant the "squall hook" in the barogram, shall have brought the summit of the cumulus into electric communication with the positively charged region of the cirrus.

As for the forecasting, it takes on two different forms, according to the manner in which the existence of the squall zone is recognized. When the zone is still over the Atlantic, as revealed by the pattern of the isobars, its arrival over the continent may be predicted with a degree of probability equal to that of the arrival of the depression of which it forms an integral part. With this degree of probability one may forecast the development of squall winds at all those points on the continent which will be swept by the squall zone as it marches parallel with itself from west to east. One ought to add that its passage will release rains at all those points where the atmosphere may be sufficiently charged with clouds and that thunderstorms will occur at all points, less numerous now, where the clouds shall have sufficiently lofty summits. But since one does not know whether the depression is moving or not, one will not be able to say precisely the hour when the wind squalls will develop at this or that station. Nevertheless one may estimate, from the mean speed (30 km. per hour) of displacement of depressions,

[2] Compare, among others, *W. J. Humphreys:* Unusual display of false cirrus. Bull., Mount Weather Observatory, 1909, v. 2, pt. 3, p. 133-5.—C. A., jr.

an approximation to the probable time when the squalls, with their probable cortège of rains and thunderstorms, will appear over the continent, as well as the times of transit for more easterly points.

The situation is altogether different if the effective presence of a squall zone on terra firma is reported telegraphically to the Bureau Central, which from that moment on would be able to keep in touch with its passage over all the points successively swept by the wind of the squall. Two or three hours would then suffice for the bureau to recognize the orientation and speed of displacement of the squall zone (just as the railways keep track of the progress of a train), and it would be able to advise points farther east of the exact time, to within 15 minutes, of the passage of the squall and some hours in advance. The regions thus warned could then judge, from the local state of the atmosphere above them, whether they were merely threatened with a tempestuous wind or also with downpours and thunderstorms at the hour indicated by the Bureau Central.

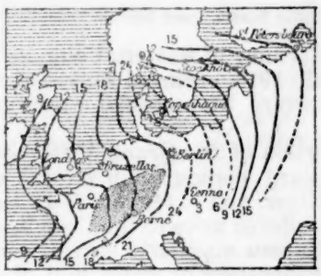

FIG. 2.—Successive positions of the "squall front" of Aug. 27-28, 1908, and the districts visited by the thunderstorm (indicated by stipple).

Unfortunately there is nothing "ephemeral" about the squall zone. It often endures for 24 hours, sometimes for 48 hours or more [see fig. 2], and travels from the Atlantic to Siberia. Its speed varies with that of the depression, an integral part of which it is, but when it has once entered the continent from the Atlantic there is nothing easier than to learn telegraphically the slight variations in its speed and to allow for them in the warnings. It would suffice were the Bureau Central authorized to receive gratis each month and at any hour of the day several hundred additional telegraphic reports. By this means it could organize a service of forecasts that would not be vague and contingent in character, but state precisely the passage at this or that hour at each point, of a tempestuous wind threatening a thunderstorm and—what is more important—a hail fall at the same time. This very simple system of warnings, which I have urged since 1894,[3] is in course of being organized beyond our borders. If we fail to take the necessary measures it will again come to pass that a French discovery will have found its practical application abroad before being taken up in France. No doubt the main thing is that it be initiated somewhere, because the results it will give will then overcome opposition everywhere; but—.

3. *Guilbert* says (**C**, p. 558):

In general the showers, rains of short duration, often abundant and sometimes torrential, are due to the passage of a cirro-nimbus. Therefore one should announce thunderstorm showers, not showers.

Durand-Gréville.—All lofty cumulus is necessarily made up of a lower portion whose droplets are above 0° C., of a middle portion where the droplets are in an undercooled state, and of a superior portion where they have become ice particles. The mushroom cumulo-nimbus is nothing more than a great cumulus whose superior portion has been fortuitously converted by a very strong ascensional current into a cap of cirrus separated from the body of the cumulus.[4] (This is the cloud which M. Guilbert, logically enough, calls a cirro-nimbus and which he considers to be made up wholly of snow crystals.) When the violent descending wind of a squall zone encounters a cumulo-nimbus of this character it demolishes the stable structure, the ice crystals meet the undercooled drops, and by incorporating the latter form the rudimentary hailstones, which continue to grow during their fall through the undercooled drops. There follows a fall of hail unless the hailstones are melted by the warm air they fall through, in which case the only result is a fall of rain. Electricity has nothing to do with the production of either the hail or the rain falls. We often have showers without a thunderstorm. But, as pointed out in section 1 (p. 559), since the existence of a lofty cumulus, together with the passage of a squall zone, are the double condition requisite for the production of a thunderstorm, therefore it follows that the shower and the thunderstorm are often concomitants, though neither is the cause or the effect of the other, a circumstance that has created the existing confusion of ideas.

4. *Guilbert* says (**D**, p. 559):

There is no occasion to introduce here hypothetical phenomena which, moreover, do not demonstrate anything; such as the rapid descent of a sheet of air to the ground, or the precipitation of cirrus upon subjacent cumulus.

Durand-Gréville.—The very narrow squall zone, rarely wider than 10 to 50 km., is throughout its length the seat of extraordinarily violent, often tempestuous winds blowing from directions averaging between W. and NW. Throughout its length the zone is bordered on either hand by weak or very weak winds, usually from the SW. It is logically impossible to admit that along a stretch of 1,000, 2,000, or even more kilometers, the weak or very weak surface wind prevailing behind the squall zone is able to feed the violent, even tempestuous surface wind within the zone; and, conversely, that the violent surface wind of the squall should feed naught but a weak surface wind or a calm in front, particularly in view of the fact that this weak surface wind has the opposite direction, as sometimes happens. It is, therefore, absolutely necessary that the squall wind should be fed from its rear by masses of obliquely descending air, and that these air masses, after having swept the ground through the breadth of the zone, should remount obliquely from that zone toward the upper regions of the depression. That excellent observer, Plumandon [of Clermont-Ferrand, France], while not seeking to establish the cause of the phenomenon, or at least not suspecting it, pointed out over 20 years ago that the cirrus-topped, mushroom cumulus [mushroom cumulo-nimbus] does not begin to produce hail until the precise moment when its summit "begins to disintegrate." In this well-established, observed fact we have the unexceptionable proof that the broad sheet of the squall wind descends from altitudes at least as lofty as those of the highest cumulo-nimbus, i. e., that it is fed by a portion of the variously sloping upper layer of air masses ascending at the center of the depression. We simply set these considerations over against M. Guilbert's

[3] In this REVIEW, June, 1898, 26: 256, Prof. Abbe suggested that all telephone and telegraph stations within 50 miles and on the NW. and SW. of cities like New York, Philadelphia, be organized into a system for reporting thunderstorms to those cities. In 1897 he had prepared a preliminary map (this REVIEW, April, 1899, 27: 157) of such stations within 100 miles of Washington, and had found that any thunderstorm 5 miles in diameter would always slip through unnoticed from the NW. and rarely be detected from the W., N., SW., or S. To catch all tornadoes the stations would have to be not more than a mile (2 km.) apart. He has repeatedly advocated such a system as M. Durand-Gréville describes.—C. A., jr.

[4] Compare W. J. Humphreys, op. cit.

theory, which requires that the squall wind be "produced by" the cirro-nimbus, just as also are the tornado (la trombe), the hail and the thunder storm. Our theory, based solely on observed facts and their direct interpretation, has the advantage of explaining why the squall wind develops without discontinuity throughout the length of the squall zone, even at those points where there does not exist any cloud, either cirro-nimbus or other kind.

5. *Guilbert* says (**E**, p. 559):

The consideration of the squall zone is insufficient, for its trajectory is indeterminate, while the thunderstorm pursues a straight-line course. * * *

Durand-Gréville.—Numerous verifications long since proved to M. Durand-Gréville that all points on the squall zone, moving along with the depression of which they are a part, follow paths parallel with that of that depression. The clouds carried along by the squall wind when it reaches them, follow a similar course scarcely modified by the component added by the direction (W. or NW.) of the squall wind. The displacement of cloud masses under the action of the squall, scarcely exceeding some tens of kilometers, their trajectory is sensibly rectilinear. Durand-Gréville has not only constantly affirmed the fact of the rectilinear movement of thunderstorms *over short distances*, but has stated the same truth with reference to the tracks of discharges of rain or hail and of tornadoes (trombes). He early pointed out, further, that this path is almost parallel with that of the low center, having a similar direction and a speed equal to that of the center. He thus has shown that, far from being indefinite, the advance of the squall zone and of all its attendant phenomena is absolute in form, in orientation, in direction, and in velocity.

A BREATHING WELL.

Under date of November 29, 1915, Mr. John Free, of New Carlisle, Ohio, sent the following account to the Weather Bureau office in Columbus, Ohio:

I have a well that puzzles our mind. It will blow out air and also take in air at different times. I have noticed this for two years. When it blows out it is an indication of rising temperature, wind, and rain. When it takes in air it denotes fair weather and falling temperature. The well is covered with cement and has a wooden pump. At the side of the pump we left a space of 14 by 4 inches for the frost pin to work back and forth. So we put a block in the space to keep the mice out, and when it blew out it sounded like steam escaping. So I thought it would blow a 10-cent horn. So I bored a hole in a block and placed the horn in the hole and it did blow. I have heard it blow for 48 hours without ceasing; and also saw it take in air for just as long. On the 26th [November, 1915?] it blew air out and it rained. On the morning of the 27th it was taking in air all day. On the next morning (28th) it blew out very strong. At 3 p. m. it was raining.

Can you explain that; did you ever see or hear of the like?

In his reply, Prof. J. Warren Smith points out that this "breathing" of wells and caves is well known to many students, although it must often escape the attention of persons less keen than our correspondent. As the reply pointed out, the phenomenon is causally related to the escape of fire damp and other gases in mines, to the variations in the flow of springs, the roiling of well water,[1] etc.

A storm center, or area of low pressure, is preceded by a region of falling atmospheric pressure, and while a locality is under the influence of this region of rapidly falling pressure the air and other gases within the earth's crust are partially released from the pressure confining them. They then tend to escape through the crevices and at the same time may press outward the waters feeding springs and wells. Thus the water in wells tends to rise, springs to flow copiously, mines and caverns to give forth air and gases during the falling pressure which precedes and accompanies the bad weather of storm centers.

Behind a storm the atmospheric pressure is increasing, thus just reversing the above processes; and under the action of the more pronounced high-pressure areas air may perhaps be even pressed into the earth's crevices. Thus the clearing and (in winter) cooling weather that precedes and accompanies anticyclonic areas would be announced by an inbreathing of such a tightly covered well as the one described above.—C. A., jr.

[1] See "Wells and storms," this REVIEW, July, 1900, 28: 293.

A TEMPERATURE INVERSION IN THE GRAND RIVER VALLEY, COLORADO.

By E. S. NICHOLS, Local Forecaster.

[Dated: Weather Bureau, Grand Junction, Colo., Dec. 9, 1915.]

In the Grand Valley of western Colorado on the morning of January 7, 1913, occurred so remarkable an inversion of temperature that special attention should be called to it.

The main portion of the Grand Valley is a southward and southwestward sloping plain on the northern side of the Grand River, and extending from the foothills of Grand Mesa 50 miles or more to the Utah line and beyond. The Weather Bureau maintains several cooperative stations in the southeastern or upper half of the valley, in addition to the regular station at Grand Junction which is about 12 miles from the upper end. All the stations referred to are equipped with Weather Bureau pattern maximum and minimum thermometers, which are exposed in instrument shelters of Weather Bureau design. At the cooperative stations the thermometers are about 5 feet above ground; while at the Weather Bureau office in Grand Junction they were, on the date in question, at a height of 44 feet above ground. The relative positions of the stations are shown in figure 1, which also gives elevations above sea level, closely approximated when not known exactly, of those that reported for the date mentioned.

In general, in this upper half of the valley, the ground slopes to the river banks on the north side of the Grand, while on the south side of that stream low bluffs rise from the water's edge or a short distance therefrom. Back of the bluffs in the upper fourth of the valley the ground is in general a nearly level bench or terrace known as "Orchard Mesa," except in the extreme upper end of the valley where the ground is at first rolling but soon merges into the foothills of Grand Mesa.

On the morning of January 6, 1913, the weather map showed the northern side of a low-pressure area over southwestern New Mexico; while high-pressure centers with maximum sea-level barometer readings above 30.6 inches and 30.8 inches, respectively, overlay the Snake River Valley and the east-central portions of the Dakotas. At Grand Junction that morning the sky was cloudless, temperature reached −6°F., dew point was −9°, and the southerly wind was light; temperature rose to a maximum of 11° during the day, which was practically cloudless and had 100 per cent of the possible sunshine.

On the morning of the 7th the southwestern disturbance had disappeared and the western peak of high pressure, with a central barometer reading above 30.6 inches,

overlay the Plateau region. The sky was again cloudless at Grand Junction, the temperature there fell to −19°F., the dew point was −23°, and the wind blew at the rate of 6 miles per hour from the southeast. As the district, during the preceding night, had been within the Plateau-region high, and as the atmosphere was clear and dry and, in its lower strata at least, quiescent, conditions were favorable to the setting up of strong temperature inversion.

FIG. 1.—Minimum temperatures at Grand Valley stations, Grand Junction fruit district, western Colorado, January 7, 1913. (Figures in curves give altitudes in feet above sea level; temperatures in °F.)

TABLE 1.—*Minimum temperatures recorded at Grand Valley stations, western Colorado, morning of Jan. 7, 1913.*

Stations.	Elevations.	Minimum temperatures.
	Feet.	*°F.*
Palisade	4,729	−23
Clifton	4,690	−29
Fruitvale	4,635	−34
Pomona	4,600	−34
Loma	4,568	−28
Hunter	4,560	−28
Fruita	4,540	−34
Orchard Mesa	4,670	−20
Grand Junction (Weather Bureau)	4,628	−19

Table 1 gives the minimum temperatures recorded at the valley stations, which are arranged in order of descending elevations, except in the cases of the Weather Bureau office and the Orchard Mesa substation. These temperatures have been entered on the outline map of figure 1. Evidently the coldest air tended to accumulate close to the ground in the middle and lower parts of the district on the north side of the Grand River. This is shown by the following conditions:

1. The highest substation reading, −20°F., was taken on Orchard Mesa, the cold air from which was evidently carried, by the southeast wind that prevailed that morning, over the bluffs lying along the river, on the north side of the mesa.

2. The highest substation reading on the north side of the river was −23° at Palisade in the upper end of the valley. Clifton, the next station down, reported −29°. Fruitvale, Pomona, and Fruita, still lower down, had the lowest readings, −34°.

3. The highest reading of all, −19°, was taken at the Weather Bureau office in the central part of the district but at the greatest elevation above ground.

Hunter and Loma, in the lower section, reported −28°, but this is undoubtedly higher than would have been observed in the lowlands near by. These stations are located on slight elevations in a somewhat rolling section. The same is true of the Fruita station to a less degree. Also, the office reading was unquestionably somewhat higher than would have been observed in the free air at the same elevation, on account of the influence of the office building and surrounding structures.

Assuming that the temperature in Grand Junction at a height of 5 feet above ground was −34°, the same as at Fruitvale and Pomona, above and below Grand Junction, respectively, and allowing 2° for the influence of the office building, we have a difference of 13° due to a difference in elevation of 39 feet.

Again, assuming that the temperature over that part of the valley lying on the north side of the Grand River opposite Orchard Mesa was, at the elevation of the top of the bluff on the south side of the river, the same as on Orchard Mesa, we may ascribe the difference between the Fruitvale and Orchard Mesa readings to difference in elevation. This elevation difference is not known exactly, but it is approximately 35 feet. Then we have a difference of 14° due to a 35-foot difference in elevation.

It may be noted in this connection that −19° is the lowest temperature on record at the Grand Junction office, not only for the period since the establishment of the regular station on January 1, 1899, but for the entire period of observation since records were begun by the cooperative observer in 1892. The effect of the extreme cold upon fruit trees, not only in the middle and lower portions of the Grand Valley, but also in other fruit districts of western Colorado, was, in places, serious. In places peach trees and young apple trees were killed outright. In other cases young wood on old apple trees and peach trees was killed, trunks of large apple trees were split open, and the wood of trunks and branches of large peach trees was badly discolored. A large percentage of the affected trees have since apparently recovered completely.

RELATION BETWEEN METEOROLOGICAL CONDITIONS IN THE NETHERLANDS AND SOME CIRCUMJACENT PLACES.[1]

By J. P. VAN DER STOK.

[*Reprinted from* Science Abstracts, Sec. A, Nov. 25, 1915, §§ 1494–1495.]

Atmospheric Pressure.

The methods of correlation are employed to ascertain to what extent deviations of pressure from the normal in Holland may be determined from the simultaneous deviations from the normal at certain surrounding stations. For reasons which are set forth, the three winter months December to February only are dealt with. In the first part of the inquiry 10-day means of pressure published by the "Deutsche Seewarte" are employed. Pressure variations at the Helder are correlated with those at Valencia (Ireland), Clermont, Milan, Neufahrwasser, and Christiansund. The partial correlation coefficients are worked out, and it is found that Clermont exercises the

[1] *See* Proc. K. Akad. Amsterdam, Sept. 8, 1915, 18: 310-327.

greatest influence on Helder, while Milan is the only one of the stations which has no appreciable effect. This is as might be expected when it is remembered that Milan falls within the influence of the Alps and the Mediterranean. Excluding Milan, it is found that the pressure oscillations at Helder may be accounted for to the extent of 94 per cent by means of the oscillations at the four remaining stations. It thus appears that local influences play only a subordinate part in the pressure variations at Helder, and that these latter are mainly controlled by the surges of pressure which pass over the station and the surrounding countries. The investigation covers the winter months only, so that this conclusion may not be applicable to the summer. For confirmation of these results two independent sets of three stations are taken and correlated with De Bilt. The results corroborate those already found, and it is concluded that barometric oscillations at a central point may be determined with great accuracy from as few as three well-chosen surrounding stations.

Difference of pressure and wind.

In a previous paper an investigation was made into the relation between the pressure gradient between certain stations and the surface wind.[2] The results were not entirely reliable, and in the present discussion statistical methods are employed to establish the connection. Variations from the mean value of the pressure differences between Flushing and five surrounding stations (x_1, x_2, . . . x_5) are related with the Flushing wind (x_6=north component, x_7=east component) by empirical equations of the type

$$x_6 = b_{61}x_1 + b_{62}x_2 + \ldots + b_{65}x_5,$$
$$x_7 = b_{71}x_1 + b_{72}x_2 + \ldots + b_{75}x_5.$$

The values of b_{61}, b_{62}, etc., are then determined from the observational data by the method of least squares. Making use of the resultant equations, it is found that a positive pressure gradient in the direction of Valencia produces a southeast wind at Flushing, in the direction of Biarritz an east wind, of Munich a northeast wind, of Neufahrwasser a northwest wind, and of Lerwick a southwest wind. The results both for velocity and direction of the wind are set out in a table, the surface wind which corresponds with each type of pressure gradient being given. A similar piece of work is carried out in which the average wind from four stations in the Netherlands is used in place of that from Flushing only, and by this means more regular results are obtained.—*J. S. Di[nes]*.

[2] *See* Proc., K. Akad. wetensch., Amsterdam, Mar. 28, 1912, **14**: 856-865. *Also in* Science abstracts, Sec. A, 1912, **15**: § 642 (p. 207).

INTERNAL STRUCTURE OF EARTH AND MOON.[1]

By H. JEFFREYS.

[*Reprinted from* Science Abstracts, Sec. A, Nov. 25, 1915, § 1500.]

A discussion is given of the various hypotheses which have been formulated as to the internal structure of the earth, considering it to have a homogeneous metallic core surrounded by a rocky crust. The hypotheses in which either the shell or the nucleus is supposed permanently elastic have been shown to be highly improbable, so that the earth has the hydrostatic form throughout, Wiechert's hypothesis being the only possible one of this type. The paper further explains the large ellipticities of the moon by supposing it to have solidified while much nearer the earth than it is now. The fact that the moon always turns the same face toward the earth is shown to be not necessarily due to internal tidal friction, as in the absence of this the amplitude of the free libration in longitude would only increase with extreme slowness. If this amplitude had been reduced to a small amount before solidification, tidal friction would not be required in order to keep it small.—*C. P. B[utler]*.

[1] *See* Mem. Roy. Astron. Soc., 1915, **60**, 6, p. 187-217.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR NOVEMBER, 1915.

By ALFRED J. HENRY, Forecaster.

[Dated: Washington, D. C., Dec. 13, 1915.]

The forecasts and warnings for November were conditioned upon the appearance and movement of 12 highs and 13 lows, as graphically portrayed on Charts II and III of this REVIEW.

Normal pressure change, October to November.[1]—Normal atmospheric pressure in the Northern Hemisphere diminishes during the period August to November over the two centers of low pressure in the North Atlantic and North Pacific, respectively. Beginning in September, however, and continuing until December the pressure increases 0.10 to 0.15 inch over large parts of the continental areas North America and Asia, this increase being most marked in Central Asia. Over the greater part of the United States, proper, pressure normally increases somewhat from October to November.

Pressure in Alaska and other centers of action.—During the current month pressure was uniformly below the normal in Alaska, the greatest negative departure being at Eagle, viz, −0.24 inch. A natural inference drawn from the pressure distribution over the Aleutians and Alaska is that when pressure is uniformly low, as it was during the current month, individual lows would develop at rather frequent intervals and pass southeastward to the northern boundary of the United States and thence eastward to the Atlantic, viz, the Great Lakes and the St. Lawrence Valley. This inference proved to be only partially correct, since the number of lows passing eastward along the northern boundary was less than usual in November, as may be seen by an inspection of Chart III of this REVIEW. On the other hand, there was a marked tendency for lows to pass southeastward, crossing the Rocky Mountains in Wyoming and Colorado and soon thereafter curving to the northeast and passing beyond the field of observation over the Great Lakes.

To what extent, if any, this movement was conditioned upon the prevailing pressure distribution over Iceland can not be stated, since no observations from that region are at present available. Pressure at the Azores, however, was below the normal, while over the western part of the Atlantic, as at Bermuda, pressure was slightly above the normal.

Movements of highs.—The movement of highs was somewhat abnormal for the month, since all but two appeared to be of Pacific origin. These two exceptions are highs Nos. III and VII of Chart II. High No. VII exemplifies in a marked degree the tendency to increasing pressure in the central portion that is noted occasionally in highs which move into the Lake region from the north or west in the spring. Pressure in the center of this high continued to increase slightly until it had passed off to sea over the Massachusetts coast. High No. III showed an increase in central pressure while passing eastward from the northern Plateau region on the 8th and 9th. This increase in pressure, however, was also observed practically simultaneously over Alaska and the Canadian Northwest. The simultaneity of the rise suggests an important exception to the generally accepted rule that the phenomena of rising and falling pressure, as displayed by the allobars, progress uniformly over the earth's surface from one point to another.

The storm winds of the 19–20th, Low No. VI.—Low No. VI advanced rapidly from the Canadian Northwest on the night of the 15th to northwestern Colorado, in 24 hours; then at a much reduced speed to Oklahoma, in the succeeding 24 hours; recurving during the night of the 17–18th to the northeast; at the same time there was developed a second center of low pressure in the primary low. This second center, on the morning of the 18th, was located over southeastern Louisiana, while the center of the primary low was over northern Arkansas. During the 18th pressure in the southern extension of the primary fell at a remarkably rapid rate and the attendant conditions gave every indication of the development of a severe storm. At the night observation of the 18th the center of the primary was over Illinois, while the secondary center had reached Columbia, S. C., with a fall of pressure of 0.87 inch in 12 hours, and high east to southeast winds along the coast from Jacksonville to Hatteras, notice of which had been previously given. According to all precedents this secondary center should have followed the coast line to southern New England but, on the contrary, it evidently merged with the primary low which on the morning of the 19th was central over Michigan, with lowest pressure 28.98 inches. Nevertheless, fresh southeast gales prevailed along the Middle Atlantic coast on the 19th, the maximum recorded velocity being 72 miles per hour at New York City. Fresh to strong gales were also experienced over the Great Lakes, particularly on Lake Erie, from the afternoon of the 19th until the afternoon of the 20th. High winds prevailed in the Lake region also on the 8th, 11th, and 29th, in connection with lows Nos. III, IV, and XII.

Low No. II, after passing off to sea over the Massachusetts coast on the 5th, apparently increased considerably in energy during that day, causing northeast gales at Nantucket, which continued for a part of the 6th. There were several periods of high offshore winds along the New England and Middle Atlantic coast, notably on the 10th, 15th, 16th, and 21st. On the 24th and 25th fairly strong northerly winds prevailed, due to a depression over the Atlantic between Bermuda and Sable Island.

Frosts.—The southeastward movement of high No. VI over Texas, the Gulf and the South Atlantic States on the 15th and 16th brought general frost to those regions; the frost along the coast districts was generally light; in the interior heavy to killing. A second general frost period ensued in the Gulf and South Atlantic States on the 30th, in connection with high No. XII.

DISTRICT WARNINGS DURING NOVEMBER.

Chicago district.—No warnings of consequence were issued during the month, as the period was quite uneventful, aside from temperature above the average.—*H. J. Cox, Professor of Meteorology.*

[1] Based upon International Greenwich noon observations, 1878–1887, as published in Report of Chief Signal Officer, 1891, p. 747.

Denver district.—On the 24th, 8 p. m., cold wave warnings were issued for eastern Colorado. Marked falls in temperature were general, the warning being fully justified in the northeastern counties.

On the 27th, 8 p. m., cold wave warnings were issued for southeastern New Mexico. This warning was justified.—*F. H. Brandenburg, District Forecaster.*

New Orleans district.—The first cold wave of the season occurred in northwestern Louisiana and in eastern and southern Texas, except at immediate coast stations on November 15. Warnings for the cold wave were issued the morning of the 14th.

Freezing temperatures occurred on several dates and warnings were issued well in advance in each case.

No general storm occurred on the West Gulf coast during the month.—*I. M. Cline, District Forecaster.*

Portland district.—The weather during the last half of November was unusually stormy and storm warnings were issued on nine different days. Those issued on the 15th, 21st–22d, and 24th–25th were the most important.

While warnings were flying, the Chilean ship *Carel Napu* was wrecked on the south shore of Vancouver Island at 1 p. m. November 25. The crew consisted of 23 persons, of whom 5 were saved and 18 were lost.—*E. A. Beals, District Forecaster.*

San Francisco district.—The month was exceptionally free from storms of even moderate severity and the precipitation reported was in the form of showers; generally scattered and of short duration.

Storm warnings were displayed on the 8th from San Francisco to Eureka, and on the 15th from Mendocino to Eureka, when moderately strong winds occurred off the coast.

Quite heavy frosts occurred in northern California on the 9th, and over the entire State from the 10th to 14th and on the 27th. These frosts were forecast, and but slight damage occurred.—*G. H. Willson, District Forecaster.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS OF NOVEMBER, 1915.

By ALFRED J. HENRY, Professor of Meteorology, in Charge of River and Flood Division.

The rainfall for the month was moderate and well distributed. Many of the larger streams throughout the country were considerably swollen due to general rains, though few attained a bankful stage, and those which reached or exceeded the flood stage occasioned no material damages as a consequence. While the rainfall for the month as a whole was not unusually heavy, there were two or three periods between November 10 and 27 of continuous rains moderate to heavy in amount. The sections visited by the heaviest rainfalls east of the Rockies together with the dates of heaviest falls are as follows: The lower Arkansas and Red River valleys, from the 9th to 15th, and on the 26th. The lower Mississippi Valley from 12th to 15th, and on 26th. The middle Mississippi and Ohio valleys on the 12th to 15th, 19th and 26th. In the Carolinas on the 19th. The heaviest rainfalls of the Ohio Valley occurred over the Cumberland watershed. The entire month was rainy on the North Pacific slope, producing swollen streams in the rivers of that region, with flood stages in the Willamette River of Oregon. The heaviest rains for this region occurred on the 12th, 16th, 18th, 23d, 25th, and 29th.

In the following table will be found the gage heights in all the rivers at points where the crest reached or closely approached the flood stage:

Flood stages in all rivers, November, 1915.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Cumberland	Burnside, Ky	50.0			47.0	15
Do	Celina, Tenn	45.0			39.6	19
Do	Carthage, Tenn	40.0			38.5	20
Do	Nashville, Tenn	40.0	19	22	41.5	20
Do	Clarksville, Tenn	46.0			44.1	21 & 22
Santee	Rimini, S. C	12.0	21	26	13.2	23
Do	Ferguson, S. C	12.0	23	28	12.6	26
Nueces	Cotulla, Tex	9.9	9	9	9.9	9
Salt	Tempe, Ariz	2.6	8	8	2.6	8
Willamette	Eugene, Oreg	10.0	26	26	14.5	26
Do	Albany, Oreg	20.0			19.6	27
Do	Oregon City, Oreg	12.0			11.0	28
Santiam	Jefferson, Oreg	10.0	18	18	11.5	18
			26	26	10.3	26
Clackamas	Cazadero, Oreg	8.0	23	23	10.0	23

Flood warnings were issued from the river district centers at Columbia, S. C., and Nashville, Tenn., in ample time in advance to allow for the removal of property in lowlands subject to damage.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

SNOW SURVEY ON COTTONWOOD CREEK, IDAHO.

By ALFRED J. HENRY, Professor of Meteorology.

In the MONTHLY WEATHER REVIEW for November, 1914, 42:634, a brief account is given of the results of a snow survey on the watershed of Cottonwood Creek, a tributary of the Boise River which enters that stream near Boise, Idaho, conducted under the direction of Section Director E. L. Wells, of Boise, Idaho. The results of a similar survey conducted over the identical watershed during March, 1915, together with the discharge measurements of Cottonwood Creek, made as before, through cooperation with the United States Geological Survey, Water Resources Branch, are now available.

The snow survey of March, 1915, indicated that the snow cover at that time contained 8,457.5 acre-feet of water available as run-off, during the melting season. Daily precipitation and discharge measurements were made from March to September, inclusive, at a point on Cottonwood Creek below the area covered by the snow survey. The total monthly precipitation in inches and hundredths and the monthly discharge in acre-feet are given in Table 1, to which have been added corresponding data for 1914:

TABLE 1.—*Total monthly precipitation and discharge, 1914–15.*

	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Total.
Precipitation, inches, 1914	0.34	2.85	1.02	0.84	0.92	T.	1.20	7.17
Precipitation, inches, 1915	0.93	1.56	5.21	0.65	0.67	0.13	0.77	9.95
Run-off, acre-feet, 1914	2,420	3,730	2,200	881	295	73	111	9,710
Run-off, acre-feet, 1915	587	791	1,130	566	183	50	93	3,400
Mean temperature departure (1914)	3.0	1.3	−2.7	−1.7	1.4	0.6	−1.4	.....
Do (1915)	4.4	5.0	−1.6	−2.7	−2.5	4.2	−1.2	.....

Run-off in 1914 was 61 per cent of water equivalent of snow.
Run-off in 1915 was 42 per cent of water equivalent of snow.

It is at once apparent that the diminished run-off of 1915 was due primarily to the diminished snowfall of the winter of 1914–15, the amount of water in the snow cover of 1915 being just about half of that of the year previous.

The total precipitation of 1915 was a little more than 2 inches greater than for the corresponding period of the previous year, but it is clear that a large part of the precipitation did not appear as run-off.

The temperature conditions during the two years were not greatly different, as may be seen from the data of the table. The precipitation of the warm season of 1915, although fairly generous in April and May, followed upon a year of exceptionally light precipitation. The winter snowfall, as before stated, was very little more than half of the preceding winter and the months of March and April were relatively warm and rapid melting must have taken place.

The run-off in March and April, 1915, was less than a quarter of that of the corresponding months in 1914, but in May, 1915, doubtless due to the fairly heavy precipitation, the run-off was 51 per cent of May, 1914. This increase over the two previous months, amounting to about 30 per cent of the whole, was maintained until the close of the season, when, for one reason or another, the run-off of September, 1915, was almost equal to

that of 1914. Since the snow is doubtless all gone by the middle of July, the run-off for the remaining portion of the season must come from the ground storage and precipitation. The latter for both August and September of both years was practically negligible; wherefore we conclude that the ground storage of the watershed was replenished by the rains of April and May, 1915.

Section Director Wells, in commenting upon the results of the survey, says:

From the foregoing it will be observed that not only was the total run-off much lighter in 1915 than in 1914, but the percentage of run-off as compared with the snow supply was much less in 1915 than in 1914, notwithstanding the fact that more rain fell during the season in 1915 than in the same period in 1914. This is probably due to several reasons:

First. The total loss by evaporation would be nearly or quite as great from a thin snow cover as from a heavier cover.

Second. The summer and fall of 1914 were abnormally dry, leaving a marked deficiency in the soil water, which had to be made up before the run-off could be materially increased.

Third. It is apparent that the summer rainfall has little effect in augmenting the flow of the streams, as compared with the winter snowfall. May, 1915, was an abnormally wet month, yet the run-off during that month was only a little more than half that for May, 1914.

During the season of 1915 the monthly discharge varied from 50 acre-feet in August to 1,130 acre-feet in May. In 1914 the monthly discharge varied from 73 acre-feet in August to 3,730 acre-feet in April.

MEAN LAKE LEVELS DURING NOVEMBER, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., December 2, 1915.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during November, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.89	579.52	571.46	244.94
Above or below—				
Mean stage of October, 1915	+0.14	−0.29	−0.53	−0.23
Mean stage of November, 1914	+0.44	−0.36	−0.01	−0.31
Average stage for November, last 10 years	+0.42	−0.77	−0.35	−0.69
Highest recorded November stage	−0.62	−3.40	−2.21	−2.88
Lowest recorded November stage	+1.39	+0.34	+0.76	+1.53
Average relation [1] of the November level to—				
October level	−0.2	−0.3	−0.3	−0.2
December level	+0.2	+0.2	+0.1	+0.1

[1] During last 10 years.

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR NOVEMBER, 1915.

By W. J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: Weatner Bureau, Washington, D. C., Dec. 31, 1915.]

TABLE 1.—*Noninstrumental earthquake reports, November, 1915.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		ARIZONA.								
	H. m.		° ′	° ′			*M. s.*			
21	0 15	Parker	34 10	114 16	4	1	1 00			Dr. Anna Nettle.
	0 15	Yuma	32 45	114 36	6	1	40		Clocks stopped	U. S. Weather Bureau.
	0 15	Yuma	32 44	114 37	6	1	40			C. J. Wood.
		CALIFORNIA.								
21	0 15	Aguanga	33 25	116 50		1	15			John B. Simmons.
	0 15	Blythe	33 35	114 38	2	1	30			C. L. Suits.
	0 15	Brawley	32 59	115 40						M. D. Witter.
	0 15	El Cajon	32 48	116 58	5	3	10	Rumbling		H. H. Kessler.
	0 15	San Diego	32 43	117 10	6	1	50		Many clocks stopped	U. S. Weather Bureau.
	0 15	Tustin	33 43	118 49	3	2	20			Mrs. Hazel Browning.
21	3 00	El Cajon	32 48	116 58	4	1	10			H. H. Kessler.
25	13 45	Julian	33 05	116 37	2	1	3	Rumbling		J. H. L. Vogt.
		NEVADA.								
17	23 35	Elko	40 51	115 45	5–6	1				(From press report.)
23	3 33	Fallon	39 30	118 48	2	1	5			F. B. Headley.
	3 33	Winnemucca	40 58	117 43	3	1	7			U. S. Weather Bureau.
		WASHINGTON.								
18	23 42	La Center	45 52	122 40	5	1	10	Loud		Joseph Bros.

TABLE 2.—*Instrumental reports, November, 1915.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see REVIEW for June, 1915, p. 289.]

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat. 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants:	*V*	T_0
E	10	16.7
N	10	15.4

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915. Nov. 21	.....	S	*H. m. s.* 0 24 42	*Sec.* 7	μ	μ	*Km.*	Beginning and end of quake obscured by microseisms.
		L_E	0 27 08	26	.....	.....	.....	
		L_N	0 27 22	24	.....	.....	.....	
		M_N	0 32 20	8	.....	17	.....	
		M_E	0 33 12	14	46	.....	.....	
		C	0 35 00	10	.....	.....	.....	

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants:	*V*	T_0
E	10	16
N	10	19.6

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915. Nov. 21	.....	P_E	*H. m. s.* 0 14 44	*Sec.* 2	μ	μ	*Km.*	The stylus of N–S was off the sheet from $0^h\ 10^m\ 16^s$ to $0^h\ 22^m\ 24^s$. Maximum given was measured to the edge of the paper.
		P_N	0 14 52	4	.....	.....	.....	
		L_N	0 15 57	.....	.....	.....	.....	
		L_E	0 15 58	.....	.....	.....	.....	
		M	0 16 38	.....	461	385	.....	
		C_E	0 18 31	7	.....	.....	.....	
		C_N	0 23 33	9	.....	.....	.....	
		F	1 26 00	.....	.....	.....	.....	
21	.....	eL	3 46 54	.....	.....	.....	.....	Probably recurrence of previous disturbance.
		M_N	3 47 18	.....	.....	10	.....	
		M_E	3 47 50	.....	20	.....	.....	
		F	3 52 00	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.

California. *Berkeley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 5	.....	.....	.....	.....	*300	*400	.....	Except when time is given, all of these tremors occured at unknown hours, being recorded during the 24 hours preceding 15h on dates given. No shocks felt except those for which time is given.
6	.....	.....	.....	.....	*200	*400	.....	
13	.....	.....	.....	.....	*200	*200	.....	
14	.....	.....	8 02 00	.....	*100	*500	.....	
15	.....	.....	.....	.....	*200	*200	.....	
17	.....	.....	.....	.....	*200	*400	.....	
19	.....	.....	.....	.....	*200	*600	.....	
20	.....	.....	.....	.....	*200	*400	.....	
21	.....	.....	0 15 00	.....	*3.175	*2,780	.....	
21	.....	.....	3 00 00	.....	*200	*200	.....	
22	.....	.....	.....	.....	*100	*400	.....	
24	.....	.....	.....	.....	*400	*700	.....	
25	.....	.....	.....	.....	*350	*350	.....	
26	.....	.....	.....	.....	*500	*400	.....	
27	.....	.....	.....	.....	*300	*300	.....	
28	.....	.....	.....	.....	*200	*200	.....	
29	.....	.....	.....	.....	*400	*800	.....	
30	.....	.....	.....	.....	*200	*200	.....	

* Amplitude on instrument.

California. *Santa Clara, University of.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.

(See Record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver. Sacred Heart College. Earthquake Station.* A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 11–12.	.....	.....	.....	.....	.....	.....	.....	Activity on both components.
14–15	.....	.....	.....	.....	.....	.....	.....	Activity on both components.
21	.....	P_N	0 10 00	.....	.....	.....	.....	Imperial Valley, Cal. Time of phases approximate, clock being repaired. P and S hardly discernible.
		P_E	0 10 00	.....	.....	.....	.....	
		S_N	0 12 00	.....	.....	.....	.....	
		S_E	0 12 00	.....	.....	.....	.....	
		iL_N	0 13 00	10–12	.....	573	.....	
		L_E	0 13 00	8–10	570	.....	.....	
		M_N	0 14 00	10–12	.....	650	.....	
		L_E	0 14 00	10–12	837	.....	.....	
		C_E	0 16 00	8– 9	137	.....	.....	
		C_N	0 17 00	7– 8	.....	175	.....	
		F_N	0 32 00	.....	.....	.....	.....	
		F_E	0 36 00	.....	.....	.....	.....	
29–30	.....	.....	.....	.....	.....	.....	.....	Intermittent activity on both components.

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

	V	T_0
Instrumental constants..	110	6

1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 1	I_u.....	P_E	7 37 12	.....	.....	.....	9,500	Microseisms present. Many small maxima.
		S.....	7 47 50	.....	.....	.....	.....	
		eL.....	8 07 24	26	.....	.....	.....	
		F.....	10 15 00	.....	.....	.....	.....	
21	III_r.....	P.....	0 20 00	.....	.....	.....	3,500	Earthquake felt in southern California.
		S.....	0 25 17	.....	.....	.....	.....	
		L.....	0 28 01	.....	.....	.....	.....	
		L?	0 29 19	.....	.....	.....	.....	
		M_N...	0 32 50	.....	.....	.....	.....	Several other large maxima.
		M_E...	0 35 20	.....	.....	.....	.....	
		F.....	2 00 00	.....	.....	.....	.....	F in microseisms.
26	I_r.....	P_N...	19 18 33	.....	.....	.....	3,470	Southwest of Panama.
		S_N...	19 23 48	.....	.....	.....	.....	
		L_N...	19 29 30	12	.....	.....	.....	
		F.....	19 45 00	.....	.....	.....	.....	F merges into microseisms.
30	.....	eL.....	5 04 10	.....	.....	.....	.....	
		F.....	5 20 00	.....	.....	.....	.....	

District of Columbia. *Washington. Georgetown University.* F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg., astatic horizontal pendulums.

		V	T_0	ϵ
Instrumental constants..	E	165	5.4	2.6
	N	143	5.2	3.4

1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 1	.....	eP_E...	7 36 34	.....	.....	.....	.....	Heavy microseisms for 24 hours. All phases masked in microseisms.
		eP_N...	7 37 01	.....	.....	.....	.....	
		eS_E...	7 48 18	.....	.....	.....	.....	
		eS_N...	7 48 39	.....	.....	.....	.....	
		L_E....	8 08 45	.....	.....	.....	.....	
		L_N....	8 09 18	.....	.....	.....	.....	
		M_E....	8 22 26	20	3	.....	.....	
		M_N....	8 24 38	17	.....	3	.....	
		F_E....	10 17 50	.....	.....	.....	.....	
		F_N....	10 20 29	.....	.....	.....	.....	
21	III_r....	eP_N...	0 24 51	9	.....	.....	.....	Phases masked in microseisms. Earthquake felt in southern California.
		eP_E...	0 25 03	.....	.....	.....	.....	
		S_N....	0 30 41	7	.....	.....	.....	
		S_E....	0 30 42	6	.....	.....	.....	
		L_N....	0 31 01	10	.....	.....	.....	
		L_E....	0 31 11	10	.....	.....	.....	
		M_N....	0 32 01	.....	.....	65	.....	
		M_N....	0 32 53	.....	.....	63	.....	
		M_E....	0 33 28	.....	21	.....	.....	
		M_N....	0 33 42	.....	.....	76	.....	
		M_E....	0 34 42	.....	42	.....	.....	
		M_E....	0 35 27	.....	52	.....	.....	
		F.....	1 30 00	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports*—Continued.

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instruments: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.9

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 1	.....	P.....	7 33 36	.....	.....	.....	.....	
		S.....	7 36 30	.....	.....	.....	.....	
		L.....	7 40 36	.....	.....	.....	.....	
		M.....	8 02 24	.....	*6,500	.....	.....	
		F.....	11 28 00	.....	.....	.....	.....	
4	.....	e.....	3 29 06	.....	.....	.....	.....	
		M.....	3 30 00	.....	*200	.....	.....	
		C.....	3 31 30	.....	.....	.....	.....	
		F.....	4 23 42	.....	.....	.....	.....	
6	.....	e.....	10 09 24	.....	.....	.....	.....	
		M.....	10 16 48	.....	*100	.....	.....	
		F.....	10 31 48	.....	.....	.....	.....	
7	.....	P.....	8 00 00	.....	.....	.....	.....	
		S.....	8 01 48	.....	.....	.....	.....	
		L.....	8 10 00	.....	.....	.....	.....	
		M.....	8 14 00	.....	*300	.....	.....	
		C.....	8 18 12	.....	.....	.....	.....	
		F.....	8 26 24	.....	.....	.....	.....	
13	.....	e.....	11 37 06	.....	.....	.....	.....	
		M.....	11 41 00	.....	*100	.....	.....	
		F.....	11 46 00	.....	.....	.....	.....	
18	.....	P.....	4 11 42	.....	.....	.....	.....	
		L.....	4 19 42	.....	.....	.....	.....	
		M.....	4 20 36	.....	*800	.....	.....	
		C.....	4 42 54	.....	.....	.....	.....	
		F.....	5 25 00	.....	.....	.....	.....	
18	.....	P.....	20 40 54	.....	.....	.....	.....	
		L.....	20 58 12	.....	.....	.....	.....	
		M.....	21 03 48	.....	*500	.....	.....	
		C.....	21 16 48	.....	.....	.....	.....	
		F.....	21 25 24	.....	.....	.....	.....	
21	.....	P.....	0 21 06	.....	.....	.....	.....	
		S.....	0 27 18	.....	.....	.....	.....	
		L.....	0 30 06	22	.....	.....	.....	
		M.....	0 35 12	.....	*6,600	.....	.....	
		C.....	1 01 48	.....	.....	.....	.....	
		F.....	3 24 18	.....	.....	.....	.....	
29	.....	e.....	10 32 00	.....	.....	.....	.....	
		M.....	10 35 24	.....	*100	.....	.....	
		F.....	10 40 00	.....	.....	.....	.....	
29	.....	e.....	14 37 30	.....	.....	.....	.....	
		M.....	14 39 18	.....	*100	.....	.....	
		F.....	14 44 48	.....	.....	.....	.....	
30	.....	e.....	5 23 06	.....	.....	.....	.....	
		M.....	5 25 00	.....	*100	.....	.....	
		F.....	5 29 00	.....	.....	.....	.....	

*Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants..		V	T_0	ε
	E	177	3.4	4.0
	N	205	3.4	3.8

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 1	.....	P_E.....	7 36 49	2- 3	.....	.....	.....	Slight tremors during much of preceding day.
		S_E.....	7 46 59	12-14	.....	.....	.....	
		L.....	.....	.....	.....	.....	.....	L not discernible.
		M_E.....	8 17 30	15-18	3	.....	.....	Record of N-S component lost.
		F.....	9 20 00	.....	.....	.....	.....	
21	.....	P_N.....	0 17 41	1- 2	.....	.....	.....	P_E, S_E, and M_E lost.
		S_N.....	0 21 10	5- 6	.....	.....	.....	
		L_N.....	0 22 44	5-10	.....	.....	.....	
		L_E.....	0 22 48	.....	.....	.....	.....	
		M_N.....	0 23 45	10-12	.....	209	.....	
		F_N.....	1 35 00	.....	.....	.....	.....	

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants..		V	T_0
	E	10	31
	N	10	29

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 21	.....	eP_N.....	0 29 10	3	.....	.....	.....	
		L_E.....	0 33 09	11	.....	.....	.....	
		L_N.....	0 30 30	10	.....	.....	.....	
		M_N.....	0 31 14	10	.....	215	.....	
		M_E.....	0 34 30	6	90	.....	.....	
		C_N.....	0 36 00	12	.....	.....	.....	
		C_E.....	0 37 00	8	.....	.....	.....	
		F_E.....	1 04 00	.....	.....	.....	.....	
		F_N.....	1 11 00	.....	.....	.....	.....	

Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacia sand over clay.

Instruments: Two Bosch-Omori, 100 kg., horizontal pendulums, undamped (mechanical registration).

Instrumental constants..		V	T_0	ε
	E	80	23	0
	N	50	25	4

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 1	.....	*O*.....	7 24 31	.....	.....	.....	9,590	eP in microseisms.
		eP.....	7 37 13	.....	.....	.....	.....	
		S_E.....	7 47 06	.....	.....	.....	.....	
		S_N.....	7 47 52	6	.....	.....	.....	
		eL_E.....	8 09 59	.....	.....	.....	.....	
		M.....	8 20 28	.....	.....	.....	.....	
		LR_N.....	9 50 36	18-20	.....	.....	.....	
		F.....	10 33 00	.....	.....	.....	.....	
21	.....	*O*.....	0 13 35	.....	.....	.....	3,900	Earthquake in Imperial Valley, Cal.
		eP_E.....	0 20 46	.....	.....	.....	.....	
		S_N.....	0 26 33	.....	.....	.....	.....	
		S_E.....	0 26 35	.....	.....	.....	.....	
		eL_E.....	0 29 54	.....	.....	.....	.....	
		eL_N.....	0 30 00	.....	.....	.....	.....	
		M_N.....	0 33 14	16	.....	† 300	.....	Maxima of E-W, undamped less than N-S, damped 4:1.
		M_E.....	0 33 58	.....	.....	.....	.....	
		M_E.....	0 35 57	.....	.....	.....	.....	
		C_E.....	0 39 50	.....	.....	.....	.....	
		F.....	1 45 00	.....	.....	.....	.....	
26	.....	e?.....	19 27 34	.....	.....	.....	.....	All phases masked by microseisms.
		L.....	19 31 46	29	.....	.....	.....	
		L.....	19 36 14 19 39 14	16-13	.....	.....	.....	
		F.....	.....	.....	.....	.....	.....	

O=time at origin.
† N-S stylus left drum, returning at 1h 35m 34s.

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants..	V	T_0	ε:1
	80	7	5:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 1	I_r.....	eP_N.....	7 41 00	.....	.....	.....	3,200	
		S_N.....	7 46 00	.....	.....	.....	.....	
		L.....	7 47 00	.....	.....	.....	.....	
		F.....	9 01 00	.....	.....	.....	.....	
21	III_r.....	eP.....	0 18 24	.....	.....	.....	2,500	
		S.....	0 22 54	.....	.....	.....	.....	
		L.....	0 24 18	.....	.....	.....	.....	
		M_N.....	0 24 18	18	.....	56	.....	
		M_E.....	0 24 24	12	34	.....	.....	
		F.....	1 20 00	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports*—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
New York. *Buffalo. Canisius College.* John A. Curtin, S. J.								
Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.								
Instrument: Wiechert 80 kg. horizontal.								
Instrumental constants..				V 80	T_0 7	ε:1 5:1		
1915. Nov. 1	.....	eP_E	*H. m. s.* 7 48 50	*Sec.*	*μ*	*μ*	*Km.*	
		eP_N	7 49 30					
		S_E	7 59 30					
		S_N	8 01 00					
		L_E	8 14 00					
		L_N	8 15 00					
		M_E	8 25 00	22	5			
		M_N	8 27 00	16		6		
		C_E	8 29 00					
		C_N	8 31 00					
		F_E	8 36 00					
		F_N	8 37 00					
21	III_T	eP_N	0 23 20					Reported in southwestern part of the United States.
		eP_E	0 24 00					
		S_N	0 28 10					
		S_E	0 29 00					
		L_N	0 30 00					
		L_E	0 30 45					
		M_E	0 31 50	10	53			
		M_N	0 32 30	9		56		
		M_E	0 32 45	8	44			
		M_N	0 33 00	6		50		
		C_E	0 33 15					
		M_N	0 35 00			72		
		C_N	0 36 00					
		F_N	1 10 00					
		F_E	1 14 00					
New York. *Fordham. Fordham University.* W. C. Repetti, S. J.								
Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.								
Instrument: Wiechert, 80 kg.								
Instrumental constants..				V E 72 N 72	T_0 7.2 7.2	ε:1 1.5:1 3.8:1		
1915. Nov. 1	.....	eP_N	*H. m. s.* 7 43 29	*Sec.*	*μ*	*μ*	*Km.*	
		eP_E?	7 43 29					
		eS_N?	7 53 39					
		eL?	8 06 04					
		M_E	8 14 11	18	15			
		M_N	8 17 48 8 25 27	18		12		Sinusoidal waves with no decided maximum.
		F_E	8 46 00					
		F_N	8 55 00					
21	.....	S_N	0 21 28					P masked by microseisms.
		S_E	0 21 35					
		L_N	0 25 58					
		L_E	0 26 58					
		M_N	0 29 43	10		358		
		M_E	0 31 18	9	219			
		F_N	1 09 00					
		F_E	1 12 00					
Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission								
Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, ——.								
Instruments: Two Bosch-Omori 100 kg.								
Instrumental constants..				V 10	T_0 20			
1915. Nov. 20	.....	P_E	*H. m. s.* 19 12 30	*Sec.*	*μ*	*μ*	*Km.* 190	Direction SW?
		P_N	19 12 45					
		L_E	19 12 51					
		L_N	19 13 06					
		M.			2,750	2,900		Pens ran off sheets during maxima; amplitudes greater than here given.
		F_E	19 29 36					
		F_N	19 31 05					
26	.....	P_E	19 34 04				198	Direction SW?
		P_N	19 34 33					
		L_E	19 34 26					
		M_E	19 34 31		25			
		L_N	19 34 55					
		M_N	19 34 58			50		
		F_E	19 35 50					
		F_N	19 36 30					

Panama Canal Zone. *Balboa Heights*—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915. Nov. 26	.....	P_E	*H. m. s.* 20 23 06	*Sec.*	*μ*	*μ*	*Km.* 198	Direction SW?
		P_N	20 23 36					
		L_E	20 23 28					
		M_E	20 23 30		625			
		L_N	20 23 58					
		M_N	20 24 04			500		
		F?						
26	.....	P?						Direction SW?
		L_E	20 26 30					
		M_E	20 26 38		200			
		L_N	20 27 00					
		M_N	20 27 10			150		
		F_E	20 32 15					
		F_N	20 34 51					
27	.....	P_E	0 14 18				183	Direction SW?
		P_N	0 14 36					
		L_E	0 14 36					
		M_E	0 14 39		40			
		L_N	0 14 58					
		M_N	0 15 04			25		
		F_N	0 16 27					
		F_E	0 16 34					
27	.....	P_E	4 16 44				328	Direction SW?
		P_N	4 17 10					
		L_E	4 17 24					
		M_E	4 17 28		100			
		L_N	4 17 50					
		M_N	4 17 52			75		
		F_E	4 20 20					
		F_N	4 22 28					
27	.....	P_E	19 04 00				212	Direction SW?
		P_N	19 04 19					
		L_E	19 04 24					
		M_E	19 04 26		100			
		L_N	19 04 43					
		M_N	19 04 49			60		
		F_E	19 06 30					
		F_N	19 07 15					
27	.....	P_E	23 19 20				212	Direction SW?
		P_N	23 19 48					
		L_E	23 19 44					
		M_E	23 19 46		50			
		L_N	23 20 12					
		M_N	23 20 18			50		
		F_E	23 21 16					
		F_N	23 21 45					
27	.....	P_E	23 22 46				212	Direction SW?
		P_N	23 23 12					
		L_E	23 23 10					
		M_E	23 23 14					
		L_N	23 23 36					
		M_N	23 23 40					
		F_E	23 24 20					
		F_N	23 24 30					
30	.....	P_E	4 49 32				357	Direction SW?
		P_N	4 49 57					
		L_E	4 50 20					
		L_N	4 50 33					
		M_N	4 50 44			800		
		M_E	4 51 00		450			
		F_E	5 01 40					
		F_N	5 02 40					

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants.. V E 10 N 10 T_0 21.4 21.1

Nov. 21	.....	P_E	0 29 12	5				
		S_E	0 33 06	10				
		L_E	0 37 56	18				
		L_N	0 38 40	28				
		M_N	0 45 00	16		10		
		M_E	0 48 04	14	20			
		C	0 58 00	14				
		F	1 17 00					

TABLE 2.—*Instrumental reports*—Continued.

Date.	Character.	Phase.	Time.	Period T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.								
Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.								
Instruments: Two Bosch-Omori, mechanical registration.								
Instrumental constants..				V	T_0			
				E 10	15			
				N 10	16			
1915			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Nov. 1	I_u.....	P_E?...	7 37 06	.....	.....	.....	9,280?	
		S.....	7 47 30	.....	.....	.....	.....	
		eL....	8 07 00	.....	.....	.....	.....	Maxima on E-W more pronounced than on N-S.
		F.....	10 00 00	.....	.....	.....	.....	
21	III_P....	P?.....	0 20 40	.....	.....	.....	3,675?	Phases masked by microseisms.
		S.....	0 26 08	.....	.....	.....	.....	
		L.....	0 29 17	12	.....	.....	.....	
		M_N....	0 33 05	.....	.....	.....	.....	
		M_E....	0 35 12	.....	.....	.....	.....	
		F.....	2 00 00	.....	.....	.....	.....	
26	.....	M.....	19 35 05	.....	.....	.....	.....	Earthquake southwest of Panama. Beginning of all phases indiscernible.
		F.....	19 45 00	.....	.....	.....	.....	
30	.....	M.....	5 04 19	.....	.....	.....	.....	All phases indistinct. Maximum very small.
		F.....	5 06 40	.....	.....	.....	.....	
Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.								
Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.								
Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.								
Instrumental constants:				V	T_0			
				120	26			
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Nov. 1	.....	P.....	7 37 03	2	.....	.....	9,340	Off Japan.
		S.....	7 47 30	.....	.....	.....	.....	
		$SR1_E$.	7 53 33	.....	.....	.....	.....	
		L.....	8 07 36	40	.....	.....	.....	
		L.....	8 10 00	20	.....	.....	.....	
		M_E....	8 17 00	20	28	.....	.....	
		M_N....	8 23 00	20	.....	52	.....	Waves from antiepicenter show well.
		M_E....	8 24 00	16	28	.....	.....	
		M_N....	8 27 00	16	.....	56	.....	
		L_E....	8 33 to 9 04 00	14-16	.....	.....	.....	
		LR...	9 51 00	20	.....	.....	.....	
		LR...	9 56 00	20-18	.....	.....	.....	
		F.....	10 30 00	.....	.....	.....	.....	
18	.....	i_E.....	4 26 06	.....	.....	.....	.....	Strong microseisms mask N-S.
		eL_E...	4 55 00	.....	.....	.....	.....	
		L_E....	4 58 00	18	.....	.....	.....	
		L_E....	5 01 00	18	.....	.....	.....	
		F.....	5 10 00	.....	.....	.....	.....	
21	.....	P_E...	0 20 34	2	.....	.....	3,520	Microseisms mask P_N.
		S.....	0 25 52	.....	.....	.....	.....	
		L_N....	0 28 48	40	.....	.....	.....	
		L_E....	0 29 00	.....	.....	.....	.....	
		M_N....	0 32 30	.....	.....	720	.....	
		M_E....	0 35 00	.....	460	.....	.....	
		L.....	1 00 00	11	.....	.....	.....	
		F.....	3 00 00	.....	.....	.....	.....	
			VERTICAL.					
					(A_Z)			
		M....	*0 34 00*	.....	*650*	.....	.....	
26	.....	P_N...	19 19 33	2	.....	.....	4,140	
		S_E....	19 25 28	.....	.....	.....	.....	
		S_N....	19 25 30	.....	.....	.....	.....	
		L_E....	19 30 48	30	.....	.....	.....	Microseisms mask L_N.
		L_E....	19 34 00	20	.....	.....	.....	
		L_E....	19 35 00	18	.....	.....	.....	
		L_E....	19 36 00	14	.....	.....	.....	
		F.....	19 47 00	.....	.....	.....	.....	

Date.	Character.	Phase.	Time.	Period T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Canada. *Ottawa, Dominion Astronomical Observatory*—Continued.								
1915.								
Nov. 30	.....	P_N?...	4 53 09	2	.....	.....	3,900?	
		S_E?...	4 59 50	.....	.....	.....	.....	
		S_N?...	4 59 51	.....	.....	.....	.....	
		eL_E?..	5 03 24	c0	.....	.....	.....	
		L_E....	5 05 00	40	.....	.....	.....	
		L_E....	5 07 00	30	.....	.....	.....	
		L_E....	5 08 00	20	.....	.....	.....	
		L_N....	5 09 00	24	.....	.....	.....	
		L.....	5 10 00	20-18	.....	.....	.....	
		F.....	5 15 00	.....	.....	.....	.....	

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

[Report for November, 1915, not received.]

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instruments: Wiechert, vertical. Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation: 1 mm. swing of boom=0.54″.

[Report for November, 1915, not received.]

SEISMOLOGICAL DISPATCHES.[1]

Rome, via Paris, Nov. 14, 1915.

The royal observatory at Catania reports that the volcano of Stromboli was in violent eruption at 9 o'clock yesterday morning, according to the Stefani agency. Great blocks of lava and ashes have fallen over the entire island. The town of Lipari, on the island of the same name, felt a shock which lasted for a short time. (Assoc. Press.)

Los Angeles, Cal., Nov. 20, 1915.

Accompanying an earthquake shock that rocked the southwest, damaged buildings in Mexico and the Imperial Valley, a volcano at Andrade, Mexico, across the line from Yuma, sprang into activity this afternoon. The shocks were felt as far north as San Diego and reported more or less heavy in all parts of the Imperial Valley. In Mexico they were reported strong. At Calexico walls were cracked and buildings damaged. (Assoc. Press; United Press.)

Canal Zone, Panama, Dec. 1, 1915. (See above Table 2, p. —.)

Ten distinct seismic disturbances were recorded at the Balboa Heights observatory during the four days from November 26 to November 29, inclusive. The first shock, intensity V on the Rossi-Forel scale of I to X, was the heaviest and was similar in many ways to the disturbance that occurred on October 1, 1913. The shocks that followed were comparatively light. The indicated distances of the disturbances varied, but all seem to have had a common origin about 195 to 225 kilometers southwest of Balboa Heights, probably in the neighborhood of Los Santos province. The disturbance that was recorded about midnight of November 29 was over 320 kilometers away, but in all probability occurred along the same fault as those previously recorded. (Assoc. Press.)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, Washington, D. C.

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Brinton, Willard C.
Graphic methods for presenting facts. New York. 1914. xii, 371 p. 26 cm.

Colombo observatory.
Report on the Colombo observatory and the meteorology of Ceylon, 1914. [Colombo. 1915.] 8, N 41 p. viii charts. 33 cm.

Connor, A. J.
The temperature and precipitation of British Columbia. Ottawa. 1915. 90 p. [4] pl. 29 cm.

Franklin, H. J., & Morse, F. W.
Reports on experimental work in connection with cranberries. Amherst, Mass. [1914.] 2 p. l., 37–68 p. 23 cm. (Mass. agric. exper. station. Bulletin no. 150.) ["Weather observations" and "Frost protection," p. 37–39.]

Granada. Observatorio meteorológico de Cartuja.
Bolétin anual, año de 1914. [In Spanish and French.] Granada. 1915. 76 p. 34½ cm.

Hamburg. Sternwarte.
Meteorologische Beobachtungen auf der Hamburger Sternwarte in Bergedorf im Jahre 1914. Hamburg. 1915. 2p.l., 49p. 28½ cm.

Japan. Central meteorological observatory.
Annual report, 1914. Meteorological observations in Japan for the year 1914. Tôkyô. 1915. 385 p. chart. 30 cm.

Liebe, Gottfried.
Wind-Elektrizität, ihre Erzeugung und Verwendung für ländliche Verhältnisse. Berlin. 1915. vii, 124 p. illus. 18½ cm.

Mahler, Karl.
Klimaprofile. 745–748 p. 2 plates. 22½ cm. (Sonderabdruck aus den Mitteilungen des Vereins für Erdkunde zu Dresden. Band II, Heft 7.)

Mauritius. Royal Alfred observatory.
Annual report of the director. Mauritius. 1915. 10 p. 34 cm.

Prussia. K. Meteorologisches Institut.
Ergebnisse der meteorologischen Beobachtungen in Potsdam im Jahre 1914. Berlin. 1915. xv, 96 p. 34 cm.

Strömberg, Gustaf.
On a method for studying a certain class of regularities in a series of observations with application to the temperature-curve of Uppsala. Västerås. 1915. 66 p. 24 cm. (Inaug.-Diss.)

Tananarive. Observatoire de Madagascar.
Observations météorologiques, 25e volume. 1913. Tananarive. 1915. vi, 273 p. 22½ cm.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

(Dated: Washington, D. C., Jan. 6, 1916.)

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

The mean pressure for the month as a whole was below the normal over most of the country. The only sections showing positive departures were the coastal portion of the Gulf States, the southern Rocky Mountain and Plateau regions, California, and central Washington. The positive departures as a rule were small, the greatest values appearing in central California. However, the negative departures were quite marked in the upper Lake region, the upper Mississippi and lower Missouri valleys, and the extreme eastern and the Rocky Mountain portions of the Canadian Provinces.

The month opened with relatively low pressure throughout the northern section of the country from the Rocky Mountain region eastward to the Atlantic. Elsewhere the pressure was near or slightly above the normal.

During the first decade, except for the occasional passage of a low area, the pressure was relatively high throughout most sections east of the Rocky Mountains, except along the northern border, where it was generally below the normal, as well as to the westward of the Rocky Mountains.

During the second and third decades extensive and well-defined low and high pressure areas followed each other across the country at somewhat frequent intervals, and the month closed with relatively high pressure throughout the southeastern districts and in the North Pacific States. Elsewhere it was near the normal, except in the Rocky Mountain region and to the eastward in the Canadian Provinces, and over the Northern States, where relatively low pressure obtained.

The distribution of the highs and lows was generally favorable for westerly and northwesterly winds along the coastal portion of the New England and Middle Atlantic States, the Missouri and upper Mississippi Valleys and upper Lake region, northerly and northeasterly along the coastal portion of the South Atlantic and East Gulf States, southerly and southwesterly in the lower Lake region, the Ohio and central Mississippi Valleys, and western Gulf States. Elsewhere variable winds prevailed.

TEMPERATURE.

The eastward movement of low-pressure areas along the northern border, referred to in the REVIEW for October, continued during the early part of November, and unusual warmth, with much bright sunshine, was a marked feature of the weather during the greater part of the first decade. The average temperature during the period from the 1st to 8th, inclusive, was above the normal in all parts of the country, the period being specially warm in the great central valleys and Southwest, where the departures from normal ranged from 10 to 18 degrees per day.

By the 8th an area of high pressure had advanced to the upper Mississippi Valley and a change to considerably colder weather overspread most northern and central districts during the next two days, but this was soon followed by falling pressure in the West, and warmer weather again overspread most central and eastern districts. In the far Northwest, however, the weather had steadily grown colder and during the period from about the 9th to 13th, inclusive, cooler weather overspread most of the western Mountain and Pacific Coast States, the average temperatures for the 5-day period ranging from 5 to 9 degrees below the normal over much of the region. To the eastward of the mountains, however, the weather, except for short periods, continued warmer than usual, especially so over the Gulf and South Atlantic States, where some unusually high temperatures for November were recorded and the average temperatures for the period ranged from 10 to nearly 15 degrees above the normal.

By the morning of the 13th the pressure had become high over the northern Plateau region and the first zero temperatures of the season were reported from exposed points in Wyoming and southern Montana, with flurries of snow in the mountains from central Colorado northward.

During the 14th to 16th the cool area advanced into the Gulf and South Atlantic States, with freezing temperatures and the first killing frost of the season over much of the cotton belt, thereby ending further growth of that staple for the season in practically all districts.

With the passage off the South Atlantic coast of the above-mentioned cold area, warmer weather followed in most districts and it continued warmer than usual for so late in November over all portions of the country save in the Lake region and portions of the Ohio and Mississippi valleys, where the average temperatures from about the 14th to 22d were near or slightly less than normal.

During the last decade of the month pressure was again low over northern districts, and temperatures continued higher than usual over nearly all portions of the country, except that near the end of the month a change to cooler weather overspread the Plains region and Southwest.

At the close of the month temperatures were again rising in the Middle West, and they were near or above the normal for the season over most other districts.

Monthly averages.—As in October, the monthly means of temperature were above the normal over all parts of the country save for small areas in the Plateau region and near the Pacific coast, where they were normal or slightly below. Over the central valleys the month, as a whole, was decidedly warm, the excess above the normal ranging very generally from 5 to 7 degrees, or slightly more. In the more eastern districts the excess was generally somewhat less, and along the immediate Atlantic

coast the monthly averages were, as a rule, only slightly higher than normal.

Day temperatures.—With much bright sunshine during the month, the days were correspondingly warmer and maximum temperatures were unusually high for the season of the year.

From about the 4th to 7th the day temperatures over much of the central portions of the country were as high as or higher than had previously been recorded in November during a period of 40 years or more. This was especially true in Iowa and portions of surrounding States where on the 7th the extremes of previous years were exceeded by from 3 to 7 degrees. At Madison, Wis., the maximum on the 7th was 6 degrees higher than had been reported in any previous November during about 60 years of record. Again, about the 12th, the day temperatures were unusually high over the Southeastern States, especially near the south Atlantic and east Gulf coasts.

Night temperatures.—Clear weather at night favored radiation, and the mimimum temperatures were moderately low, as compared with the day temperatures, but the extremes of November for other years were not reached in any portion of the country, nor were they closely approached save in a few instances. Freezing temperatures were reported from all districts save along the immediate south Atlantic coast, over the southern portions of the Gulf States, at the lower elevations of Arizona and California, and along the Pacific coast.

Temperatures of 0°F. were reported from points in the northern Plains and northern Rocky Mountain regions, and temperatures of 10° or lower occurred as far south as Colorado and northern Arizona.

PRECIPITATION.

The early part of November, 1915, was remarkably free from storms of any character, bright sunshiny weather prevailing in most districts till near the end of the first decade, when a storm of considerable intensity moved from Colorado to the upper Lake region, accompanied by thunderstorms and considerable rain in portions of the Mississippi Valley and Lake region.

On the morning of the 10th a low area was observed over Colorado, which developed considerable energy during the following 24 hours, by which time it had moved rapidly to the western end of Lake Superior. In its course over the Great Plains region it was attended by high southerly winds, reaching tornadic force in portions of Kansas. At Great Bend, in that State, several large flouring mills were destroyed, a number of persons were killed, and large property losses resulted. Over other districts in Kansas, and to the northeastward, high winds, with thunderstorms, prevailed and heavy rains occurred locally. This storm passed to the northward of the Great Lakes during the 12th, but during its progress considerable rain fell on the 11th and 12th from central Texas northeastward to the lower Lakes.

During the 14th and 15th a storm of considerable intensity moved from the Texas coast northeastward to New England, giving the first general rain of the month over the districts to eastward of the Mississippi, the falls being quite heavy in portions of the Gulf States and Ohio Valley. At the same time rain set in over the far Northwest, and some heavy falls were reported from points in Oregon and Washington.

On the morning of the 18th low pressure had developed in the Southwest and during the day two storm centers formed and advanced to the northeastward, one over the Southeastern States and the principal one from the vicinity of Arkansas to the Great Lakes. During the night of the 18th the two storms appear to have united, and at 8 a. m. of the 19th the combined center was over Lake Michigan as a low pressure of marked force. High winds accompanied the storm in the Lake region and along the north Atlantic coast, and precipitation was general and heavy in many districts to eastward of the Mississippi, the rain turning to snow in portions of the upper Mississippi Valley and the Lake Superior region.

On the 25th general cloudy conditions had overspread the central valleys, and during the following 24 hours rains occurred in the Mississippi Valley districts, with local heavy storms in the southern portion, especially in Arkansas, where in the vicinity of Hot Springs a tornado of marked severity occurred, a number of persons being killed and considerable property damage sustained. During the 26th this storm lost energy and disappeared to the northward of the Great Lakes, but more or less precipitation occurred over the eastern districts. Only scattered precipitation occurred during the latter part of the month, except that a storm of moderate intensity moved from the middle Plains region to the upper Lakes near the end, and light rains or snows prevailed in the vicinity of the path.

For the month, as a whole, precipitation was, as a rule, moderate and did not differ greatly from the November normal, although in Tennessee and portions of the adjoining States the amounts for the month totaled 6 or 7 inches, being about 2 inches more than the normal, and some local heavy falls occurred along the southeastern coast of the Florida Peninsula. In the Atlantic Coast States less than the normal amounts occurred, the greatest deficiencies appearing in the District of Columbia and portions of Maryland and Virginia.

In the Plains States, the Rocky Mountain region, and the central and southern portions of the Plateau districts the precipitation for the month was generally light, as is usual for this season of the year, while in western Texas and portions of New Mexico the month was rainless.

In the central and southern Pacific coast districts the amounts were generally less than 2 inches, being somewhat less than the usual fall for November, but to the northward they ranged from 4 to 15 inches, and did not differ greatly from the normal, except in the more northern portions, where less than the average amounts for November occurred.

Snowfall.—Snow fell throughout most sections of the country, except in the South Atlantic and Gulf States and along the Pacific coast. The falls were light over most districts, except in the mountain regions of the West, where in some sections rather heavy falls occurred in the higher regions of Washington, Oregon, and Idaho.

GENERAL SUMMARY.

Considering all portions of the country and the month, as a whole, it may be safely stated that rarely have the weather conditions for an entire month been so generally favorable for all agricultural interests. Over the principal corn-growing States the early part of the month was without material rainfall and greatly favored the drying of the immature portions of the crop.

The generally mild weather favored the growth of wheat in all districts to eastward of the Rocky Mountains, and, with the exception of some of the later sown, the crop is reported in good condition to enter the winter

period. In the far Northwest lack of moisture during the early part of the month prevented plowing and sowing, and rains during the latter part still further delayed operations. As a result, fall seeding is still unfinished.

The continuation of warm weather in the South during the first half of the month favored the maturing of considerable late cotton, especially in Oklahoma, where the crop had continued late. Killing frost about the middle of the month, however, closed the season over practically all portions of the belt.

Over the southern trucking districts all fall work was well advanced. The ripening of citrus fruit was delayed, however, in Florida by warm weather, but in California the crop is maturing in the northern districts and shipments have begun.

Pastures continued green throughout the month in many districts, affording sufficient feed for stock, which is reported in good condition to enter the winter in all districts, save in the far Southwest, where drought has prevailed for some time, and in portions of the Northwest, where much fodder was injured by frost and the supply of winter feed is short.

Average accumulated departures for November, 1915.

District.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	° F.	° F.	° F.	Ins.	Ins.	Ins.	0–10		P. ct.	P. ct.
New England	42.0	+2.6	+14.2	2.08	−1.50	−5.60	5.8	0.0	70	− 8
Middle Atlantic	45.9	+1.7	+11.2	1.35	−1.50	−3.00	5.1	−0.2	69	− 6
South Atlantic	57.3	+3.2	+ 7.4	1.62	−1.30	−7.30	3.2	−1.3	70	− 8
Florida Peninsula	72.7	+2.1	− 3.6	2.43	+0.20	−4.00	4.0	−0.5	76	− 4
East Gulf	59.1	+3.4	+ 7.5	2.74	−0.80	−0.60	3.4	−1.2	73	− 3
West Gulf	60.9	+4.5	+ 1.5	1.90	−1.20	−4.50	4.5	−0.1	67	− 7
Ohio Valley & Tennessee	48.5	+3.6	+ 1.0	3.82	−0.40	−2.20	5.1	−0.6	70	− 3
Lower Lakes	42.1	+3.0	+ 1.5	1.96	−1.00	−1.40	7.0	−0.3	73	− 4
Upper Lakes	38.1	+3.8	+ 9.7	3.22	−0.40	−2.10	7.4	+0.3	78	− 2
North Dakota	20.5	+5.0	+18.1	1.01	+0.30	−0.50	5.7	+0.3	79	0
Upper Mississippi Valley	43.2	+5.5	+ 5.7	2.68	+0.70	+6.30	6.1	+0.8	71	− 3
Missouri Valley	44.2	+6.7	+ 3.1	1.16	−0.10	+7.70	4.5	−0.3	66	− 5
Northern slope	34.9	+2.9	+ 5.6	0.57	−0.20	+2.40	6.0	+1.2	66	− 1
Middle slope	47.6	+5.9	− 3.8	0.48	−0.50	+7.50	3.6	−0.3	57	− 5
Southern slope	54.4	+3.5	− 6.7	0.05	−1.20	+1.00	2.9	−2.3	47	−16
Southern Plateau	51.8	0.0	−15.3	0.23	−0.40	+0.60	2.4	−0.4	38	− 5
Middle Plateau	40.1	+0.5	+ 0.1	0.56	−0.40	−1.60	5.4	+1.5	55	− 3
Northern Plateau	38.4	−0.3	+16.1	1.98	+0.60	0.00	8.2	+2.4	71	− 3
North Pacific	44.5	−0.6	+21.6	8.12	+0.80	−6.40	8.5	+1.0	80	− 4
Middle Pacific	52.2	−0.9	+ 7.5	1.87	−1.30	+1.50	5.0	+0.5	73	− 2
South Pacific	58.3	+1.2	+13.7	0.68	−0.40	+2.50	3.4	+0.1	62	− 5

LOCAL STORMS DURING NOVEMBER.

The following notes of severe local storms have been taken from official reports to the Weather Bureau:

Arkansas.—Two tornadoes occurred in Arkansas on November 25, 1915, one at Hot Springs, at about 3:15 p. m., and one at Stamps and Bodcaw, at about 3:30 p. m.

The storm at Stamps and Bodcaw developed the characteristics of a tornado, the funnel-shaped cloud and the rotary winds being plainly evident. Several persons were injured and property valued at $25,000 was destroyed. The storm at Hot Springs, however, destroyed much more property and attracted the more attention because of the number of persons killed.

The Hot Springs tornado was first seen about 6 miles directly south of that town at about 3:10 or 3:15 p. m. and disappeared over Indian Mountain at 3:25 or 3:30 p. m., traveling about 7 miles in fifteen minutes, or at a rate of about 30 miles per hour. The path of the storm was about 9 miles long and varied from a few rods to one-fourth of a mile in width. An excellent description of the storm was given by Mr. T. C. Yerkes, clerk at the Arlington Hotel, who was at the top of Hot Springs Mountain and saw the tornado when it first formed in the southern portion of Hot Springs Creek Valley. He said:

> The tornado looked like a large balloon with a long tail from which smoke was escaping as it swayed from one side to the other, the end of the tail touching the ground most of the time as it came swinging along. At first it appeared as though it were coming directly over the mountain, but when about 2½ miles south of town it turned to the east, just touching the outskirts, then curved to the north again and crossed Indian Mountain into Saline River Valley. Wisps of cloud were continually forming and rushing into it from all sides. It took the tornado about 15 minutes to pass. We were preparing to run down the other side of the mountain, but when it changed its course we saw there was no danger and stayed to watch it. We saw heavy rain accompanying and following it and ran down to the hotel, but were drenched before we reached it. The roaring, grinding noise that accompanied the storm was almost deafening.

Although the storm was not so intense as many that have occurred, 10 persons were killed, 45 injured, and property valued at $300,000 was destroyed. The loss of life and property would doubtless have been appalling if the storm had not changed its course about 2½ miles south of the town, as it was moving directly toward the residence section.

Florida.—A tornado occurred at Pace, Fla., about 8 a. m. November 26, 1915 (see below).

Kansas.—On the evening of November 10, 1915, Great Bend, a thriving town of nearly 5,000 inhabitants, was struck by the most destructive tornado that has ever been reported in Kansas. This is the latest recorded date on which a tornado has occurred in Kansas, the next latest being November 8, 1870, in Republic County.

The Great Bend storm caused the death of 11 persons, injured between 50 and 75 more, and destroyed property in and near the city valued at approximately a million dollars. It first appeared about 16 miles southwest of Great Bend. Moving toward the northeast it next touched the ground at the Moses and Clayton south ranch, where about 1,000 sheep were killed. From there it swept across the southeast corner of Great Bend, demolishing everything in its path, which was from two to three blocks wide and sharply defined. The day had been unusually windy at Great Bend, but about 7 p. m. there was a lull for a few minutes, and at 7:07 p. m. the storm broke. The roaring that accompanied it was commonly described as being "like the sound of a hundred locomotives."

Owing to the total destruction of the electric light and water works plant the city was left in darkness, which greatly hampered the work of rescuing and caring for the injured.

Besides the electric light and water works plant, several large flouring mills, grain elevators, the Santa Fe passenger and freight depots, and about 125 residences were either destroyed or badly damaged.

The last evidence of the storm was found just west of Claflin, about 18 miles northeast of Great Bend. Altogether its path was about 35 miles long and not more than a quarter of a mile wide.

The second tornado of November 10 occurred near Pratt about 8:30 p. m., moving in a northeasterly direction from a point 2 miles south of Pratt to one 2 miles east. Its path was about 100 feet wide and sharply defined. The funnel-shaped cloud was not seen on account of the darkness, but the effects of the storm leave little doubt regarding its character. As it passed over no towns property destruction was comparatively

small, and no lives were lost, though there were some very narrow escapes and one person was injured. The value of the property destroyed, which includes chiefly farmhouses, barns, live stock, and crops already housed, was about $15,000.

The third storm formed about 10 p. m. a few miles southwest of Zyba (4 miles south of Peck, Sumner County) and moved northeastward, causing the death of 3 persons at Zyba and 1 at Derby, 10 miles to the northeast. Twenty-eight persons were injured by this storm, which also destroyed property to the estimated value of $50,000. Its path was 16 miles long, about one-eighth mile wide, and sharply defined. The funnel-shaped cloud was not seen on account of the darkness.

TORNADO AT PACE, FLA., NOVEMBER 26, 1915.

William F. Reed, jr., local forecaster at Pensacola, Fla., reports that a tornado occurred at Pace, Fla. ($\phi = 30° 35'$ N.; $\lambda = 87° 14'$ W.) on November 26, 1915. Moderate to fresh southerly gales occurred at Pensacola between 8 p. m. November 25 and 8 a. m. of the 26th, the highest 5-minute rate being 48 miles per hour from the southwest at 7:05 a. m. on the 26th and the extreme rate 55 miles from the southwest at 7.01 a. m. On the morning of November 26 thunderstorms were occurring in the southern end of a low-pressure trough over the Mississippi Valley. At Pensacola portions of a rainbow had been observed in the west and northwest at 6:45 a. m.; at 6:55 a. m. threatening conditions were rapidly approaching; rain began at 7:02 a. m. This rain ended at 10:30 a. m., having amounted to 0.38 inch, of which 0.32 fell between 7 and 8 a. m. Faint peals of thunder were heard from 7:14 to 9:20 a. m.; lightning was observed from 7:18 to 8:20 a. m. No damage was done at Pensacola.

After reaching Pensacola the storm moved north-northeastward, doing the greatest damage at Pace, Fla. While on its way the storm appeared at Floridatown on Escambia Bay as a straight blow from the south-southwest, lasting only a few minutes and doing no damage.

The tornado seems to have reached Pace at 8 a. m. as a black funnel-shaped cloud coming from the southwest and moving toward the northeast. A distinct whirl was observed in the cloud which rose and fell at short intervals and was accompanied by "a roaring noise like 50 freight trains," and one person reports that the noise was mostly above the tree tops. There was some lightning and heavy rainfall for 20 minutes. The general direction in which trees and débris lay was from southwest to northeast; the length of the path at this place was 3 miles, with a width of one-fourth mile where the greatest destruction occurred. Another observer, whose house was moved 6 inches and whose sheds were carried 100 yards, found the path to be about 100 yards wide. No one was killed.

WEATHER CONDITIONS OVER THE NORTH ATLANTIC DURING NOVEMBER, 1914.

The data presented are for November, 1914, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. The accompanying Chart IX (XLIII–131) shows for November, 1914, the averages of pressure, temperature, and the prevailing direction of the winds at Greenwich mean noon, together with the location and courses of the more severe storm tracks of the month.

During the month as a whole the distribution of the mean atmospheric pressure over the greater part of the ocean was similar to the normal, as shown on the Meteorological Chart of the North Atlantic Ocean for November.

The Azores high was of less area and of slightly greater intensity than normal, while its crest was about 6° west of its usual position.

The center of the Icelandic low was too far north to be shown on the chart, but judging from the nearly normal location of the 29.70 isobar, it is probably not far from its normal position. Over the northern-central part of the ocean there were more than the average number of gales reported, although in many instances it was impossible to show the movement of the storm from day to day on account of lack of observations.

On Chart III (XLII–78), showing the tracks of low areas for November, 1914, published in the REVIEW for that month, a low (I on Chart IX) is shown that first appeared on November 1, over the Pacific Ocean off the coast of Vancouver Island. This moved in an easterly direction through southern Canada, and on the morning of the 5th was on the Atlantic coast near Chatham, Canada. On November 6, 1914, the apparent center was near latitude 51° N. and longitude 46° W., several vessels to the eastward reporting winds of from 40 to 48 miles an hour, with rain, while in the central and southern portions of the area moderate winds and fog prevailed. On November 7 it had moved northeastward and was central near latitude 59° N. and longitude 26° W., the wind having decreased in force. By the 8th the storm had moved beyond the limits of the chart.

A second low (II on Chart IX) appeared in Alberta near latitude 51° and longitude 115° on the morning of November 11. This moved in a southeasterly direction and passed over Chicago on the night of the 12th; thence curving slightly to the northward it reached the Canadian coast near Chatham on the morning of the 14th, moderate winds of from 36 to 40 miles prevailing. On November 15 it was central near latitude 49° and longitude 45°, the barometer having fallen slightly and the winds increased to a maximum of 48 miles. On the 16th it had moved to latitude 51° and longitude 36°, where one vessel reported a barometer reading of 29.05 inches and several encountered winds of 64 miles an hour, accompanied by hail and rain. No trace of this storm could be seen on the 17th, and it had evidently moved in a northerly direction off the limits of the chart.

On November 20 a low with a minimum barometer reading of 29.41 inches was central off the Atlantic coast near Boston, while there was a high area with a maximum reading of 30.84 inches near latitude 47° N. and longitude 46° W. The unusually steep gradient of 1.43 inches between these two areas was accompanied by heavy winds, and a number of vessels reported westerly and southwesterly gales of 64 miles an hour. By the 21st the low had moved a short distance to the north and the high about 10° to the east. The distance between the two lows had increased, the gradient was weaker and the force of the wind was less in the intermediate region, the highest velocity recorded being 48 miles an hour.

On November 25 a low appeared with its apparent center near latitude 59° and longitude 32°, although it was too far north to plot accurately. Between the forty-fifth and fifty-fifth parallels and thirty-fifth and forty-fifth meridians several ships reported westerly and southwesterly gales, with snow and hail, one vessel encountering a wind of 75 miles an hour, which was the highest velocity reported during the month. From the 27th to the 30th there was a succession of westerly gales along the fiftieth parallel, although the centers of the low areas from which they originated were all too far north to appear on the chart.

Fog.—The Meteorological Chart of the North Atlantic Ocean for November shows that the maximum amount of fog for the 6-year period from 1901 to 1906 occurred in the vicinity of the banks of Newfoundland, where the percentage was from 30 to 35. For November, 1914, in the 5-degree square from latitude 45° to 50° and longitude 45° to 50° fog was observed on six days, or a percentage of 20, while it was also below the normal on all other portions of the ocean.

Temperature.—As a whole the temperature was not far from the normal, although off the coast of Scotland and in mid-ocean between the thirty-fifth and fortieth parallels there were positive departures of from 2° to 4°, while in the waters adjacent to the American coast they ranged from +1° at the fiftieth parallel to −1° off the southern coast of Florida and from +2° to +4° in the Gulf of Mexico. The departures at the different land stations on the Atlantic coast were as follows: St. Johns, Newfoundland, +0.1°; Sydney, Cape Breton Island, +0.9°; Halifax, Nova Scotia, −0.7°; Portland, Me., −1.0°; Boston, +1.5°; New York, 0.0°; Atlantic City, +0.5°; Norfolk, −0.2°; Hatteras, −1.1°; Jacksonville, −0.2°; Key West, −1.3°; Tampa, +0.8°; New Orleans, +0.6°; Galveston, +0.2°; and Corpus Christi, +1.6°.

PRECIPITATION.

On the northern steamship routes hail occurred on the 11th, 12th, 13th, 14th, 15th, 17th, 25th, 26th, 27th, 28th, and 30th, and snow on the 13th, 20th, 24th, 25th, 28th, 29th, and 30th.

Maximum wind velocities, November, 1915.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
		Mis./hr				*Mis./hr.*	
Block Island, R. I.	15	56	w.	Mt. Tamalpais, Cal.	16	58	nw.
Do	16	52	w.	Do	23	51	sw.
Do	19	50	se.	Do	26	62	n.
Do	21	50	w.	Nantucket, Mass.	5	50	ne.
Buffalo, N. Y.	1	54	w.	New York, N. Y.	2	60	w.
Do	2	50	nw.	Do	9	57	nw.
Do	12	50	w.	Do	15	61	nw.
Do	13	58	w.	Do	19	71	se.
Do	15	52	w.	Do	20	51	sw
Do	19	56	sw.	Do	21	56	w.
Do	20	74	w.	North Head, Wash.	15	82	s.
Do	21	52	w.	Do	17	66	s.
Do	27	56	w.	Do	21	60	se.
Do	29	70	w.	Do	22	72	se.
Charleston, S. C.	18	54	se.	Do	24	67	se.
Chattanooga, Tenn	20	55	sw.	Do	25	62	sw.
Cheyenne, Wyo.	7	52	nw.	Do	28	52	s.
Do	18	54	w.	Pittsburgh, Pa.	21	50	w.
Do	19	54	w.	Point Reyes Light,			
Do	20	64	w.	Cal.	6	64	nw.
Do	21	50	w.	Do	7	60	nw.
Do	22	72	w.	Do	8	56	s.
Do	25	50	w.	Providence, R. I.	2	58	nw.
Do	26	54	w.	Do	16	54	nw.
Columbia, S. C.	18	52	sw.	Do	19	62	se.
Del Rio, Tex.	25	50	nw.	Reno, Nev.	15	52	w.
Drexel, Nebr.	10	54	sw.	Do	23	55	w.
Duluth, Minn.	8	51	sw.	Roswell, N. Mex.	10	50	sw.
Do	19	56	nw.	St. Paul, Minn.	7	54	w.
El Paso, Tex.	10	51	w.	Sandy Hook, N. J.	2	53	w.
Erie, Pa.	18	60	se.	Do	15	54	w.
Do	19	71	se.	Do	19	60	se.
Do	20	52	w.	Savannah, Ga.	18	62	se.
Do	21	50	sw.	Sault Ste. Marie,			
Galveston, Tex.	17	50	nw.	Mich.	9	52	nw.
Grand Haven,				Sioux City, Iowa.	22	55	nw.
Mich.	19	57	w.	Tatoosh Island,			
Do	20	50	w.	Wash.	15	54	nw.
Green Bay, Wis.	1	50	w.	Do	17	64	se.
Do	11	52	s.	Do	21	56	w.
Hatteras, N. C.	18	50	s.	Do	22	54	s.
Do	19	55	se.	Do	24	52	e.
Lexington, Ky.	19	50	sw.	Do	25	74	sw.
Louisville, Ky.	19	52	sw.	Toledo, Ohio	11	50	s.
Mt. Tamalpais, Cal.	7	52	nw.	Trenton, N. J.	19	54	se.
Do	8	58	sw.	Wichita, Kans.	10	54	sw.
Do	12	53	n.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, November, 1915.

Section.	Temperature.								Precipitation.					
			Monthly extremes.								Greatest monthly.		Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Section average.	Departure from the normal.	Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		Ins.	Ins.		Ins.		Ins.
Alabama	56.6	+2.5	Ashville	89	10†	Hamilton	20	16	3.12	+0.02	Riverton	8.61	Eufaula	0.69
Arizona	51.4	−0.2	Parker	100	1†	2 stations	0	11	0.90	−0.01	Carr's Ranch	3.06	Yuma	T.
Arkansas	54.8	+3.9	Dardanelle	88	1	2 stations	17	15†	5.40	+1.50	Springbank	9.14	Fort Smith	1.24
California	50.8	−2.1	Blythe	96	3	Bridgeport	−18	10	1.96	−0.85	Crescent City	16.47	14 stations	0.00
Colorado	36.0	+0.7	Sedgwick	93	5	Dillon	−30	28	0.99	+0.05	Savage Basin	4.92	2 stations	0.00
Florida	67.1	+2.5	Middleburg	92	11	Wausau	24	30	2.57	+0.18	Fort Lauderdale	10.20	Panama City	0.77
Georgia	57.2	+2.4	Albany	90	11†	Blue Ridge	19	17	2.15	−0.43	Quitman	4.19	Goat Rock	0.37
Hawaii (October)	73.3	.....	Waianae, Oahu	92	2†	Volcano Observatory, Hawaii.	42	29	8.25	.....	Kopiliula, Maui	33.22	Waiawa, Kauai	0.00
Idaho	34.2	−1.5	Murtaugh	78	1	Pierson	−24	13†	2.33	−0.03	Elk Creek	8.54	Hotspring	0.25
Illinois	45.7	+4.8	McLeansboro	85	1	Dakota	10	22	2.46	−0.28	Equality	4.49	Urbana	1.02
Indiana	45.7	+3.3	Hickory Hill	88	6	Whitestown	13	30	2.85	−0.28	Rome	6.04	Collegeville	0.88
Iowa	40.2	+5.2	Keosauqua	83	7	Rock Rapids	− 5	14	1.94	+0.43	Rockwell City	4.86	Cedar Rapids	0.30
Kansas	48.2	+5.1	Chanute	89	6	Russell Springs	− 4	29	0.56	−0.67	Oswego	2.42	Deerfield	0.00
Kentucky	49.8	+3.8	Bardstown	85	1	4 stations	16	30	4.78	+1.19	Alpha	8.03	Scott	2.65
Louisiana	62.6	+3.4	3 stations	95	1†	Kelly	22	30	2.64	−0.79	Plain Dealing	8.19	Paradis	0.30
Maryland-Delaware	45.0	+0.2	College Park, Md	79	1	Oakland, Md	14	23	1.38	−1.10	Oakland, Md	3.19	Solomons, Md	0.44
Michigan	38.9	+3.1	Jackson	78	1	Humboldt	− 1	16	2.68	+0.21	Munising	5.92	Harbor Beach	1.11
Minnesota	31.4	+2.6	6 stations	74	6	Windom	−13	14	1.90	+0.87	Duluth (near)	4.34	Beardsley	0.03
Mississippi	57.8	+2.6	Edwards	88	7	2 stations	21	30	4.61	+1.24	Booneville	8.22	Pascagoula	1.50
Missouri	49.5	+4.9	2 stations	87	6†	Bethany	12	15	2.76	+0.33	Koshkonong	5.25	St. Joseph	0.82
Montana	32.4	+0.8	Busteed	79	3†	Bowen	−21	28	0.99	+0.02	Haugan	5.57	Chinook	0.00
Nebraska	41.2	+4.8	Grand Island	88	7	Mitchell	1	29	0.62	−0.06	Blair	3.13	Paxton	0.01
Nevada	40.1	+0.9	Logan	88	4	Gold Creek	− 7	14	0.47	−0.20	Jack Creek	2.74	4 stations	0.00
New England	39.6	+2.3	2 stations	73	1	Van Buren, Me	1	25	2.52	−0.86	Bar Harbor, Me	4.22	Fairfield, Me	1.21
New Jersey	44.0	+1.1	Indian Mills	75	1	Culvers Lake	16	18	1.60	−1.75	Bergen Point	3.11	Trenton	0.96
New Mexico	43.5	+0.3	San Jon	91	5	Red River Canyon	−14	13	0.21	−0.47	Chama	1.55	33 stations	0.00
New York	39.4	+2.1	Port Jervis	72	1	3 stations	5	19†	2.25	−0.59	Raquette Lake	4.42	Dannemora	0.41
North Carolina	51.5	+2.1	Kinston	88	12	Jefferson	15	30	2.40	−0.37	Rock House	6.33	Pinehurst	0.73
North Dakota	27.8	+2.0	2 stations	71	5	Hannah	−10	22	0.90	+0.30	Crosby	4.44	Walhalla	T.
Ohio	44.3	+3.2	5 stations	80	7†	Ironton	11	30	2.68	−0.07	Jackson	4.86	Bucyrus	0.98
Oklahoma	53.9	+3.8	Enid	92	5	Kenton	8	29	0.69	−1.41	Fairland	2.83	7 stations	T.
Oregon	40.7	−1.3	2 stations	75	2	Whitaker	− 5	13	7.03	+2.24	Glenora	27.46	Beckley	0.37
Pennsylvania	42.1	+1.4	2 stations	79	1	2 stations	13	18	2.18	−0.61	Edinboro	5.32	Milford	0.22
Porto Rico	76.8	0.0	5 stations	97	1†	Aibonito	54	3	9.35	+1.55	Barceloneta	42.59	Guanica Centrale	0.70
South Carolina	56.3	+2.5	Blackville	88	9	6 stations	24	16†	2.36	+0.02	Mountain Rest	4.74	Winthrop College	1.09
South Dakota	36.1	+4.2	Fairfax	81	6	Pine Ridge	− 4	29	0.58	+0.06	Hardy Range Sta.	3.75	4 stations	T.
Tennessee	51.9	+3.7	Palmetto	86	1	Carthage	14	30	6.31	+2.76	Wildersville	9.62	Mountain City	1.55
Texas	60.0	+3.0	5 stations	95	1†	Stratford	9	29	1.01	−1.32	Jefferson	8.21	32 stations	0.00
Utah	38.0	+0.1	Springdale	86	5	Scofield	−15	26	1.18	+0.26	Farmington	3.87	2 stations	T.
Virginia	42.4	+1.5	Doswell	87	11	Burkes Garden	14	30	1.51	−0.91	Mendota	3.53	Williamsburg	0.69
Washington	37.9	−2.3	Wahluke	72	1	Snyders Ranch	− 5	30	6.32	+0.50	Yale	24.06	Irene Mountain	0.92
West Virginia	45.2	+2.7	2 stations	85	1†	Bayard	11	23	3.07	+0.51	Terra Alta	5.99	Nuttallburg	1.15
Wisconsin	35.4	+3.2	6 stations	77	7†	Hayward	− 5	22	3.37	+1.63	Florence	5.74	Ashland	1.20
Wyoming	31.8	−0.3	Pinebluff	78	2	3 stations	−20	27†	0.88	+0.06	Snake River, Y.N.P.	4.28	Fort Laramie	T.

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations, making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year.*

TABLE I.—*Climatological data for United States Weather Bureau stations, November, 1915.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.													Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.								Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*			%	*In.*	*In.*		*Miles*					*0–10*	*In.*	*In.*
New England.							**42.0**	**+ 2.6**												**70**	**2.08**	**− 1.5**									**5.8**		
Eastport	76	67	85	29.81	29.90	−0.11	38.5	+ 1.7	56	1	44	25	25	33	18	36	32	77	2.16	− 1.9	11	10,386	n.	48	e.	20	3	12	15	7.2	T.	....
Greenville	1,070	6	....	28.74	29.94	.....	32.6	.....	56	1	39	11	17	26	29	....	....	....	2.56	.....	11	....	....	....	....	....	....	....	....	....	7.7	....
Portland, Me.	103	82	117	29.84	29.97	− .07	40.8	+ 3.2	66	1	48	25	18	34	22	35	28	66	2.77	− 1.0	10	7,622	sw.	44	se.	19	13	6	11	5.1	T.	....
Concord	288	70	79	29.66	29.98	− .08	40.0	+ 3.2	67	1	48	22	17	31	31	....	....	....	2.97	− 0.4	10	4,488	nw.	29	nw.	10	14	5	11	4.9	0.5	....
Burlington	404	11	48	29.51	29.96	− .09	38.1	+ 4.4	64	1	44	19	18	32	28	....	....	....	1.72	− 0.9	13	9,790	s.	48	s.	19	7	7	16	6.6	T.	T.
Northfield	876	12	60	29.01	29.99	− .06	35.4	+ 3.4	66	1	44	14	18	27	38	31	26	74	1.43	− 1.2	14	5,580	s.	35	s.	19	7	9	14	6.5	3.6	....
Boston	125	115	188	29.84	29.98	− .07	45.4	+ 4.2	72	1	52	29	18	38	23	39	33	68	2.14	− 2.0	9	8,046	w.	38	w.	15	13	5	12	5.1	0.2	....
Nantucket	12	14	90	29.96	29.97	− .08	45.8	+ 0.6	64	2	51	33	18	41	21	41	37	71	2.13	− 1.2	10	13,611	nw.	50	ne.	5	8	9	13	6.1	T.	....
Block Island, R. I.	26	11	46	29.97	30.00	− .06	45.8	+ 0.5	67	2	51	33	18	40	20	42	37	74	2.24	− 1.6	10	15,266	nw.	56	w.	15	10	3	17	6.2	....	....
Narragansett Pier	....	9	....	.....	.....	.....	43.4	+ 1.1	68	2	52	23	18	34	28	....	....	....	2.37	.....	10	.....	w.	.....	.....	.....	17	4	9	....	T.	....
Providence	160	215	251	29.80	29.98	− .09	42.8	+ 2.4	69	2	50	27	18	35	24	37	31	66	1.67	− 2.2	9	10,176	nw.	62	se.	19	11	10	9	4.9	0.3	....
Hartford	159	122	140	29.83	30.01	− .07	42.8	+ 3.3	69	1	51	26	27	35	30	37	32	69	1.75	− 2.1	11	5,474	sw.	48	se.	19	10	8	12	5.8	T.	....
New Haven	106	117	155	29.89	30.00	− .07	44.6	+ 3.3	69	2	52	27	23	37	26	38	32	68	1.90	− 1.7	11	6,920	sw.	46	e.	19	11	7	12	5.2	T.	....
Middle Atlantic States.							**45.9**	**+ 1.7**												**69**	**1.35**	**− 1.5**									**5.1**		
Albany	97	102	115	29.89	30.00	− .08	40.8	+ 2.4	70	1	48	24	25	34	28	36	31	72	2.11	− 0.7	8	5,370	s.	35	se.	19	8	8	14	6.0	0.1	....
Binghamton	871	10	69	29.04	29.99	− .10	40.6	+ 3.0	68	1	48	20	18	33	32	....	....	....	1.28	− 1.0	10	3,783	nw.	29	nw.	2	5	5	20	7.3	0.3	T.
New York	314	414	454	29.68	30.03	− .06	45.4	+ 1.4	68	1	52	30	23	38	21	39	33	66	1.09	− 2.4	8	13,915	nw.	71	se.	19	7	9	14	6.2	T.	....
Harrisburg	374	94	104	29.66	30.07	− .04	43.3	+ 1.6	74	1	51	26	30	36	27	38	32	67	1.45	− 0.9	9	5,359	nw.	32	w.	20	9	8	13	5.6	T.	....
Philadelphia	117	123	190	29.93	30.06	− .04	47.4	+ 2.5	70	2	55	32	30	40	26	41	35	67	1.22	− 1.8	9	7,397	nw.	35	se.	19	12	10	8	4.7	T.	....
Reading	325	81	98	29.71	30.06	.....	44.2	.....	74	1	52	27	18	36	29	38	32	69	2.13	− 1.0	8	5,293	nw.	33	se.	19	8	10	12	5.9	T.	....
Scranton	805	111	119	29.16	30.04	− .05	42.1	+ 3.0	71	1	50	23	18	34	32	37	32	73	1.37	− 0.9	8	5,616	sw.	37	w.	2	5	7	18	7.1	0.1	....
Atlantic City	52	37	48	30.01	30.07	− .03	46.6	+ 1.1	72	2	55	27	30	38	27	42	36	71	1.25	− 2.0	9	5,820	nw.	34	se.	19	11	9	10	5.1	....	....
Cape May	18	13	49	30.07	30.09	− .01	48.0	+ 0.6	73	1	55	29	23	40	23	....	....	....	1.16	− 2.1	8	7,115	nw.	37	se.	19	12	11	7	4.3	....	....
Sandy Hook	22	10	57	30.01	30.03	.....	46.0	.....	67	1	51	31	23	40	16	41	37	75	1.33	.....	8	13,090	w.	60	se.	19	13	6	11	5.1	....	....
Trenton	190	159	183	29.83	30.04	.....	44.5	.....	69	1	53	27	30	36	26	38	33	71	0.96	− 2.5	7	8,569	w.	54	se.	19	10	9	11	5.1	T.	....
Baltimore	123	100	113	29.94	30.08	− .03	47.0	+ 1.2	76	1	55	29	30	39	25	40	34	65	1.59	− 1.3	8	4,651	nw.	36	sw.	19	12	14	4	4.5	T.	....
Washington	112	62	85	29.95	30.07	− .05	46.2	+ 1.2	77	1	56	25	23	36	28	39	33	68	0.93	− 1.8	8	4,745	nw.	37	nw.	15	9	15	6	4.5	....	....
Lynchburg	681	153	188	29.33	30.09	− .04	48.1	+ 2.0	79	9	60	27	30	36	40	40	34	67	1.66	− 1.1	4	4,747	nw.	34	w.	21	14	11	5	4.5	....	....
Norfolk	91	170	205	30.00	30.10	− .01	52.4	+ 1.2	78	2	60	29	30	44	28	45	39	64	0.87	− 1.8	8	9,513	sw.	48	sw.	19	16	10	4	3.7	....	....
Richmond	144	11	52	29.94	30.10	− .02	49.2	+ 0.4	78	9	60	26	30	38	34	42	35	67	0.63	− 1.8	8	6,067	sw.	39	sw.	21	18	7	5	3.6	....	....
Wytheville [a]	2,293	40	47	27.70	30.12	.....	45.6	.....	73	11	58	23	22	33	39	38	33	71	1.93	− 1.1	9	3,974	w.	29	w.	20	14	6	5	4.2	0.4	....
South Atlantic States.							**57.3**	**+3.2**												**70**	**1.62**	**− 1.3**									**3.2**		
Asheville	2,255	70	84	27.74	30.12	− .02	48.5	+ 3.4	74	7	59	24	16	38	37	41	35	67	2.20	− 1.1	9	7,067	nw.	39	e.	18	18	6	6	3.5	T.	....
Charlotte	773	153	161	29.26	30.11	− .02	53.3	+ 2.9	78	9	63	29	30	44	29	45	39	66	1.96	− 0.9	5	8,286	sw.	48	e.	18	19	6	5	3.4	....	....
Hatteras	11	12	50	30.09	30.10	− .01	57.3	+ 0.6	76	2	64	38	30	51	25	52	48	75	1.22	− 3.4	6	10,936	n.	55	se.	19	16	9	5	3.9	....	....
Manteo	12	4	46	.....	.....	.....	53.6	.....	79	2	64	27	17	43	....	....	....	....	1.17	− 3.4	3	.....	n.	.....	.....	.....	20	7	3	....	....	....
Raleigh	376	103	110	29.70	30.11	− .02	52.8	+ 2.6	79	9	64	28	30	42	32	44	37	64	1.35	− 1.0	7	5,839	sw.	48	se.	18	16	9	5	4.1	....	....
Wilmington	78	81	91	30.04	30.12	.00	56.8	+ 2.7	81	12	68	31	30	46	32	49	44	71	0.99	− 1.5	5	5,392	ne.	43	s.	18	20	8	2	2.4	....	....
Charleston	48	11	92	30.07	30.12	.00	61.4	+ 3.3	83	12	70	35	30	53	25	55	51	73	1.65	− 1.2	2	7,802	ne.	54	se.	18	20	6	4	2.7	....	....
Columbia, S. C.	351	41	57	29.74	30.13	+ .01	57.2	+ 3.4	82	9	68	31	16	46	33	48	41	66	1.90	− 0.3	6	5,337	sw.	52	sw.	18	18	9	3	3.4	....	....
Augusta	180	89	97	29.97	30.12	− .01	57.4	+ 3.5	81	9	69	32	17	46	36	50	46	77	2.70	− 0.2	4	4,150	nw.	38	ne.	18	22	4	4	2.8	....	....
Savannah	65	150	194	30.05	30.12	.00	62.4	+ 4.9	84	12	72	35	30	53	25	55	50	72	1.58	− 0.8	3	9,118	ne.	62	se.	18	20	6	4	3.0	....	....
Jacksonville	43	203	245	30.06	30.11	+ .01	66.0	+ 4.7	84	13	74	37	30	58	26	59	54	74	1.07	− 1.1	6	8,624	ne.	46	s.	18	21	6	3	3.0	....	....
Florida Peninsula.							**72.7**	**+ 2.1**												**76**	**2.43**	**+ 0.2**									**4.0**		
Key West	22	10	64	30.03	30.05	+ .03	75.5	+ 1.2	84	18	80	60	30	71	14	69	67	78	1.78	− 0.6	6	8,023	ne.	34	n.	19	19	7	4	3.7	....	....
Miami	23	71	79	30.05	30.08	.....	73.2	+ 1.2	82	18	78	51	30	69	18	67	64	74	2.54	0.0	8	6,915	e.	26	ne.	4	13	8	9	4.9	....	....
Sand Key	23	39	77	30.00	30.03	+ .01	75.0	.....	80	18	77	60	30	73	9	70	67	76	1.27	.....	5	13,159	ne.	34	nw.	19	16	10	4	3.9	....	....
Tampa	35	79	96	30.06	30.10	+ .02	69.3	+ 3.9	86	12	78	42	30	60	25	62	58	76	2.98	+ 1.3	4	4,769	n.	31	s.	18	17	8	5	3.6	....	....
East Gulf States.							**59.1**	**+ 3.4**												**73**	**2.74**	**− 0.8**									**3.4**		
Atlanta	1,174	190	216	28.87	30.13	.00	54.2	+ 2.3	76	9	63	28	30	46	24	47	40	65	1.53	− 1.9	6	8,893	nw.	42	w.	19	13	8	9	4.4	....	....
Macon	370	78	87	29.72	30.12	− .01	57.1	+ 3.8	82	12	69	31	16	45	37	49	46	77	1.95	− 1.2	4	4,042	nw.	30	s.	26	20	6	4	2.9	....	....
Thomasville	273	8	57	29.82	30.12	.00	61.7	+ 3.2	86	12	74	29	30	49	35	52	50	82	1.67	− 1.0	5	3,354	nw.	25	sw.	19	19	7	4	2.6	....	....
Pensacola	56	140	182	30.06	30.12	+ .01	63.1	+ 3.5	81	2	71	37	16	55	24	57	52	73	2.65	− 1.1	3	8,882	ne.	48	sw.	26	20	6	4	2.7	....	....
Anniston	741	9	57	29.34	30.15	+ .03	54.1	+ 2.2	80	10	66	25	30	42	37	....	....	....	3.19	− 0.2	9	4,029	nw.	27	w.	19	17	8	5	3.2	....	....
Birmingham	700	11	48	29.36	30.14	+ .02	56.1	+ 2.0	81	10	66	28	16	46	29	48	41	66	3.54	+ 0.2	8	5,344	s.	36	se.	26	16	8	6	3.8	....	....
Mobile	57	125	161	30.05	30.11	.00	61.8	+ 4.3	81	2	71	37	30	52	26	56	52	75	3.32	− 0.4	6	7,101	n.	37	n.	15	18	12	0	3.0	....	....
Montgomery	223	100	112	29.88	30.14	+ .02	58.6	+ 2.9	82	11	70	31	16	47	33	50	44	67	2.24	− 0.9	7	4,349	w.	31	sw.	14	16	11	3	3.2	....	....
Meridian	375	85	93	29.72	30.12	.00	57.6	+ 4.4	81	2	69	28	30	46	36	50	46	78	2.56	− 1.6	5	4,035	s.	27	w.	19	15	8	7	4.4	....	....
Vicksburg	247	65	74	29.84	30.12	.00	59.3	+ 3.4	82	2	69	34	15	49	34	51	46	70	5.22	+ 1.0	7	5,677	se.	43	nw.	25	16	9	5	3.9	....	....
New Orleans	51	76	84	30.05	30.11	+ .01	66.2	+ 5.6	86	12	74	41	16	58	26	59	56	78	2.29	− 1.5	5	4,991	se.	29	nw.	14	14	14	2	3.5	....	....
West Gulf States.							**60.9**	**+ 4.5**												**67**	**1.90**	**− 1.2**									**4.5**		
Shreveport	249	77	93	29.82	30.09	− .02	59.3	+ 4.0	84	8	70	33	15	49	29	51	46	69	4.14	+ 0.1	9	5,838	s.	35	s.	25	16	8	6	4.0	....	....
Bentonville	1,303	11	44	28.64	30.02	− .09	52.3	+ 5.6	81	6	63	24	15	41	31	....	....	....	2.50	− 0.5	6	5,442	s.	30	s.	10	14	11	5	3.5	1.2	....
Fort Smith	457	79	94	29.55	30.03	− .08	55.8	+ 5.9	86	8	67	29	30	45	36	47	40	63	1.24	− 2.0	7	6,840	e.	43	w.	11	14	8	8	4.4	T.	....
Little Rock	357	139	147	29.69	30.07	− .05	55.5	+ 4.0	81	6	65	29	30	46	31	48	42	67	5.63	+ 1.0	7	7,517	s.	38	w.	28	17	4	9	4.4	....	....
Brownsville	57	3	40	.....	.....	.....	70.2	.....	88	8	82	42	19	58	37	....	....	....	0.14	.....	2	.....	s.	.....	.....	.....	....	....	....	....	....	....
Corpus Christi	20	69	77	30.05	30.07	.00	68.0	+ 4.6	91	25	76	42	15	60	33	61	57	75	0.22	− 2.2	5	9,059	se.	44	s.	25	12	14	4	4.1	....	....
Dallas	512	109	117	29.51	30.06	.....	59.7	.....	86	8	71	31	15	49	35	....	....	....	1.08	.....	6	8,005	se.	36	sw.	25	14	12	4	3.7	....	....
Fort Worth	670	106	114	29.32	30.04	− 0.6	60.1	+ 5.0	87	8	72	28	29	48	37	49	39	54	0.29	− 1.3	2	8,512	s.	38	sw.	25	12	11	7	4.5	....	....
Galveston	54	106	114	30.04	30.10	+ 0.1	67.0	+ 4.1	81	2	73	43	15	61	31	61	57	72	1.47	− 2.6	6	8,977	s.	50	nw.	17	22	4	4	2.8	....	....
Houston	138	111	121	29.94	30.09	.....	65.0	+ 3.7	86	7	75	35	15	55	39	....	....	....	1.51	.....	6	6,316	se.	40	nw.	25	17	7	6	3.7	....	....
Palestine	510	64	72	29.53	30.06	− .05	61.2	+ 4.3	84	2	71	38	15	51	30	54	49	72	2.48	− 1.2	7	5,290	s.	30	s.	25	18	6	6	3.4	....	....
San Antonio	701	109	132	29.34	30.07	− .01	63.8	+ 4.6	87	8	75	33	15	52	33	54	46	61	0.29	− 1.5	3	5,806	s.	40	nw.	25	16	10	4	3.3	....	....
Taylor	582	55	63	29.48	30.09	+ .01	61.6	+ 3.9	86	8	74	30	29	49	36	....	....	....	0.70	− 1.9	4	6,726	s.	41	w.	25	15	12	3	3.7	....	....

[a] 5 days missing.

TABLE I.—*Climatological data for United States Weather Bureau stations, November, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.							Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*				°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
							48.5	+ 3.6													70	3.32	− 0.4									5.1		
Chattanooga	762	189	213	29.31	30.13	−0.01	53.4	+ 3.1	78	6	63	28	16	44	31				46	40	67	4.60	+ 1.0	9	6,316	w.	55	sw.	26	14	9	7	4.1		
Knoxville	996	93	100	29.03	30.10	− .03	51.6	+ 4.5	78	8	62	27	16	41	32				44	38	68	5.48	+ 1.9	9	3,838	sw.	27	sw.	28	15	8	7	3.9	T.	
Memphis	399	76	97	29.68	30.11	− .01	55.9	+ 4.5	80	10	64	32	15	48	24				49	43	67	7.05	+ 2.5	7	7,357	s.	46	nw.	19	18	3	9	4.2		
Nashville	546	168	191	29.51	30.10	− .02	52.8	+ 4.1	80	1	62	26	30	43	34				45	38	62	6.75	+ 2.9	8	7,855	se.	42	se.	26	16	5	9	4.1		
Lexington	989	193	230	28.99	30.07	− .05	48.8	+ 4.1	76	7	58	17	30	40	33							3.90	+ 0.4	12	12,372	sw.	50	sw.	19	15	8	7	4.3	0.2	
Louisville	525	219	255	29.48	30.07	− .05	49.6	+ 3.3	78	6	58	21	30	41	30		43	37			68	3.88	− 0.3	8	10,624	sw.	52	sw.	19	12	8	10	5.0	T.	T.
Evansville	431	72	82	29.57	30.05	− .07	50.4	+ 5.1	78	1	55	24	30	42	28		44	38			70	3.40	− 0.7	8	6,834	s.	34	s.	16	12	11	7	5.0	T.	
Indianapolis	822	194	230	29.12	30.02	− .08	45.5	+ 3.9	76	7	54	18	30	37	28		40	35			71	3.05	− 0.5	12	10,381	s.	42	w.	19	7	12	11	6.0	0.5	T.
Terre Haute	575	96	129	29.38	30.01	.....	47.0	.....	80	6	57	19	30	37	33		40	35			71	3.59	.....	9	8,771	s.	39	s.	26	5	20	5	5.8	0.7	
Cincinnati	628	11	51	29.36	30.05	− .07	46.6	+ 2.0	76	7	56	19	30	38	27		40	35			70	2.34	− 0.9	11	7,104	sw.	40	w.	20	8	15	7	5.6	0.5	T.
Columbus	824	173	222	29.15	30.04	− .07	44.4	+ 3.0	74	11	53	20	30	36	29		39	34			71	1.97	− 1.1	13	10,053	s.	44	w.	20	9	10	11	5.5	0.7	T.
Dayton	899	188	216	29.04	30.02	.....	45.3	+ 3.2	75	7	54	20	30	36	26		40	35			75	2.22	− 0.7	13	9,398	sw.	46	sw.	28	9	12	9	5.2	0.4	T.
Pittsburgh	842	353	410	29.12	30.04	− .06	45.2	+ 2.3	74	11	54	22	30	36	29		39	33			69	2.37	− 0.2	16	9,468	sw.	50	w.	21	8	7	15	6.3	0.4	T.
Elkins	1,940	41	50	27.99	30.10	− .02	42.8	+ 3.2	76	11	56	19	30	30	44		36	32			74	3.10	+ 0.2	18	3,554	w.	28	se.	18	8	9	13	5.9	3.8	2.8
Parkersburg	638	77	84	29.41	30.08	− .04	47.0	+ 3.8	77	11	57	24	30	37	32		40	35			71	3.32	+ 0.5	13	4,807	se.	29	nw.	28	13	7	10	5.0	0.1	T.
Lower Lake Region.							42.1	+ 3.0													73	1.96	− 1.0									7.0		
Buffalo	767	274	280	29.12	29.96	− .09	42.4	+ 3.1	68	11	49	24	18	36	27		38	33			75	1.86	− 1.5	8	16,438	w.	74	w.	20	3	12	15	7.2	5.4	
Canton	448	10	61	29.47	29.96	.....	37.7	+ 3.8	63	1	45	15	18	31	34		.....	.....			.....	1.25	− 2.2	11	8,810	w.	44	w.	20	8	9	13	6.1	1.2	T.
Oswego	335	76	91	29.59	29.97	− .08	40.5	+ 1.4	65	1	46	21	18	35	24		37	32			74	2.61	− 0.8	13	10,015	s.	39	nw.	15	4	7	19	7.5	6.0	
Rochester	523	97	113	29.40	29.99	− .06	41.7	+ 3.8	66	1	49	24	18	35	27		36	31			70	2.06	− 0.7	15	7,534	sw.	37	sw.	20	4	8	18	7.2	3.4	
Syracuse	597	97	113	29.34	29.99	− .07	40.8	+ 2.1	66	1	47	24	18	34	27		36	30			70	2.21	− 0.5	13	9,714	sw.	46	nw.	2	5	7	18	7.2	0.6	
Erie	714	130	166	29.19	29.97	− .09	43.2	+ 2.1	73	11	50	25	30	37	25		38	33			71	2.39	− 1.2	15	14,492	sw.	71	se.	19	2	7	21	7.7	9.0	6.0
Cleveland	762	190	201	29.16	29.99	− .08	43.9	+ 3.5	73	11	51	24	30	37	26		39	33			70	1.84	− 0.9	15	11,889	sw.	47	sw.	29	3	11	16	7.1	0.4	
Sandusky	629	62	103	29.29	29.98	− .10	43.8	+ 3.0	73	11	51	23	30	37	25		39	34			72	1.61	− 1.1	14	11,246	sw.	42	w.	20	3	10	17	7.2	0.4	T.
Toledo	628	208	243	29.29	29.98	− .09	43.7	+ 4.0	71	8	51	24	30	37	24		38	33			71	1.78	− 0.9	13	12,691	sw.	50	s.	11	6	9	15	6.3	0.4	T.
Fort Wayne	856	113	124	29.06	30.00	.....	42.8	+ 2.2	75	7	51	22	30	35	33		38	34			78	1.64	.....	8	8,694	sw.	38	s.	26	6	10	14	6.3	1.2	
Detroit	730	218	245	29.15	29.96	− .10	42.3	+ 3.7	71	8	48	23	30	36	24		38	34			76	2.02	− 0.6	13	10,589	w.	44	w.	20	5	9	16	6.7	0.7	0.1
Upper Lake Region.							38.1	+ 3.8													75	3.22	+ 0.4									7.4		
Alpena	609	13	92	29.22	29.90	− .11	38.1	+ 4.4	68	8	44	22	17	32	24		35	32			82	2.93	+ 0.4	16	10,993	se.	49	se.	19	2	7	21	7.7	4.7	2.2
Escanaba	612	54	60	29.20	29.88	− .15	36.2	+ 4.5	63	1	42	16	16	31	30		33	29			76	4.39	+ 2.1	12	8,058	nw.	37	s.	11	4	8	18	7.1	4.0	T.
Grand Haven	632	54	92	29.22	29.92	− .12	41.2	+ 3.2	68	7	48	24	17	34	28		37	33			75	2.28	− 0.2	15	11,705	w.	57	w.	19	4	11	15	6.6	3.7	T.
Grand Rapids	707	70	87	29.15	29.93	− .12	41.6	+ 3.5	68	8	49	24	30	35	29		37	33			76	1.52	− 1.0	11	6,217	w.	31	w.	19	6	3	21	7.2	3.6	0.5
Houghton	684	62	72	29.09	29.82	− .20	34.8	+ 3.3	62	11	39	19	17	30	25		.....	.....			.....	3.84	.....	16	8,504	w.	48	w.	8	0	3	27	9.4	9.1	1.5
Lansing	878	11	62	28.98	29.93	.....	39.8	+ 3.0	71	8	47	22	30	32	29		35	32			81	2.23	− 0.2	13	6,094	se.	25	sw.	11	5	6	19	7.2	7.6	1.8
Ludington	637	60	66	29.20	29.90	.....	40.0	.....	66	7	46	20	17	34	28		38	36			85	2.37	.....	10	11,019	w.	42	w.	12	5	7	18	7.3	0.4	T.
Marquette	734	77	111	29.07	29.89	− .16	35.6	+ 3.7	64	11	40	20	22	31	29		32	28			75	3.79	+ 1.0	17	9,180	nw.	38	nw.	8	1	3	26	8.9	12.2	T.
Port Huron	638	70	120	29.24	29.95	− .10	40.8	+ 4.0	72	8	47	25	16	34	28		37	33			79	1.98	− 0.7	13	9,825	w.	38	se.	19	4	9	17	7.1	0.9	T.
Saginaw	641	48	82	29.23	29.93	.....	40.2	.....	71	8	47	24	17	33	30		36	34			81	2.33	0.0	13	8,702	w.	40	s.	11	5	6	19	7.5	1.8	1.0
Sault Ste. Marie	614	11	61	29.17	29.88	− .13	35.3	+ 4.6	62	11	40	18	16	31	23		33	30			82	5.40	+ 2.5	19	9,805	se.	52	nw.	9	0	3	27	9.3	18.3	4.5
Chicago	823	140	310	29.05	29.95	− .12	44.2	+ 5.0	75	7	51	23	30	37	26		39	34			68	2.03	− 0.5	10	10,820	w.	43	s.	11	9	10	11	5.7	0.7	T.
Green Bay	617	109	144	29.22	29.89	− .15	37.3	+ 4.8	66	11	44	16	22	31	32		33	29			76	2.87	− 0.9	13	9,827	w.	52	s.	11	2	8	20	7.7	1.9	
Milwaukee	681	119	133	29.17	29.92	− .13	40.8	+ 4.7	68	7	48	20	22	34	30		37	33			76	1.82	− 0.2	10	7,874	w.	37	sw.	11	12	7	11	5.5	2.9	
Duluth	1,133	11	47	28.64	29.89	− .15	29.8	+ 0.5	52	6	36	4	22	24	22		28	25			85	3.27	+ 1.7	9	10,370	w.	56	nw.	19	2	14	14	7.0	1.0	
North Dakota.							29.5	+ 5.0													79	1.01	+ 0.3									5.7		
Moorhead	940	8	57	28.90	29.94	− .13	29.4	+ 5.0	58	3	37	− 1	16	22	27		27	25			85	0.78	− 0.2	6	6,994	nw.	32	nw.	8	12	3	15	5.7	1.3	0.1
Bismarck	1,674	8	57	28.14	29.97	− .10	32.6	+ 6.6	68	5	42	8	29	23	33		28	23			76	0.57	− 0.1	4	8,633	nw.	44	nw.	18	10	13	7	4.7	1.7	T.
Devils Lake	1,482	11	44	28.29	29.91	− .15	26.3	+ 3.7	62	5	34	0	30	18	29		24	21			84	0.60	− 0.1	12	8,935	w.	38	w.	12	11	4	15	6.2	4.0	1.5
Williston	1,872	40	47	27.90	29.93	− .13	29.7	+ 4.5	64	4	38	1	14	21	40		26	21			71	2.08	+ 1.5	5	6,312	nw.	36	w.	11	5	15	10	6.3	4.2	T.
Upper Mississippi Valley.							43.2	+ 5.5													71	2.68	+ 0.7									6.1		
Minneapolis	918	10	208	28.90	29.90	.....	35.4	.....	68	7	42	13	16	29	23		.....	.....			.....	3.62	+ 2.4	6	9,943	nw.	44	nw.	19	7	6	17	6.9	5.1	
St. Paul	837	201	236	28.98	29.90	− .16	35.3	+ 4.4	67	7	42	14	29	28	24		.....	.....			.....	2.64	+ 1.3	6	10,600	nw.	54	w.	7	7	7	16	6.4	4.7	
La Crosse	714	11	48	29.12	29.90	− .17	38.1	+ 4.3	75	7	46	15	22	30	34		.....	.....			.....	3.02	+ 1.5	12	4,900	se.	33	sw.	7	4	5	21	7.4	3.1	
Madison	974	70	78	28.87	29.94	− .12	38.8	+ 4.6	76	7	47	14	22	31	33	35	30	76				3.12	+ 1.3	10	8,901	w.	38	s.	11	5	7	18	7.3	0.9	T.
Charles City	1,015	10	49	28.84	29.94	− .09	37.2	+ 4.2	76	7	46	11	15	29	32	33	28	80				2.20	+ 0.8	7	6,433	nw.	34	sw.	7	7	9	14	6.6	2.8	
Davenport	606	71	79	29.28	29.95	− .13	43.0	+ 5.5	78	7	52	19	15	33	34	38	33	74				4.0	+ 2.3	11	6,787	w.	32	w.	19	9	9	12	5.8	3.5	T.
Des Moines	861	84	97	29.02	29.94	− .14	42.6	+ 5.8	79	7	52	19	15	33	33	37	32	69				1.24	− 0.2	6	6,171	nw.	38	sw.	7	6	12	12	6.2	0.6	
Dubuque	698	81	96	29.20	29.96	− .11	41.2	+ 5.2	78	7	50	18	22	33	32	36	31	71				1.65	− 0.2	10	6,016	nw.	30	nw.	19	7	8	15	6.5	2.8	
Keokuk	614	64	78	29.29	29.98	− .11	45.6	+ 6.2	81	7	56	17	15	35	35	39	34	70				2.85	+ 1.0	6	6,979	w.	36	w.	19	10	9	11	5.3	T.	
Cairo	356	87	93	29.65	30.04	− .08	52.4	+ 5.5	81	1	61	26	15	44	28	45	38	66				4.18	+ 0.2	7	7,732	s.	38	se.	25	13	9	8	4.6	T.	
Peoria	609	11	45	29.30	29.98	− .11	43.8	+ 6.3	79	7	54	17	15	33	34	39	35	79				2.29	− 0.4	6	6,581	s.	32	w.	19	5	9	16	6.6	T.	
Springfield, Ill.	644	10	91	29.29	29.99	− .11	46.0	+ 5.3	79	7	56	19	30	36	31	40	34	67				1.60	− 1.1	8	7,503	w.	31	s.	10	10	7	13	5.7	1.5	0.1
Hannibal	534	74	109	29.40	29.98	− .11	47.0	+ 6.5	82	7	58	17	15	36	35	.....	.....	.....				3.11	+ 1.2	7	8,016	sw.	38	nw.	19	13	8	9	5.1	T.	
St. Louis	567	265	303	29.38	30.00	− .10	50.9	+ 7.5	81	6	60	23	15	42	34	43	36	62				1.97	− 0.9	6	11,811	s.	48	s.	11	11	10	9	5.3	T.	
Missouri Valley.							44.2	+ 6.7													66	1.16	− 0.1									4.5		
Columbia, Mo.	781	11	84	29.14	29.98	− .11	48.9	+ 6.5	84	6	60	18	15	38	34	.....	.....	.....				3.02	+ 0.7	7	7,528	s.	36	nw.	19	11	9	10	5.1	T.	
Kansas City	963	161	181	28.94	29.98	− .11	50.0	+ 8.5	83	6	59	27	14	41	30	42	34	58				0.87	− 1.0	5	10,558	s.	49	nw.	19	17	6	7	4.0	T.	
St. Joseph	967	11	49	28.93	29.98	.....	47.7	.....	82	6	57	23	15	38	29	40	34	63				0.82	.....	7	7,687	nw.	39	nw.	19	11	12	7	4.2	T.	
Springfield, Mo.	1,324	98	104	28.61	30.02	− .08	50.7	+ 6.3	80	6	60	24	30	41	30	43	36	63				2.66	0.0	6	9,675	s.	42	nw.	19	23	5	2	2.1	1.2	
Iola	984	11	50	28.94	30.00	− .09	49.8	+ 6.8	83	6	62	19	15	38	39	.....	.....	.....				0.31	− 1.1	7	6,905	s.	37	nw.	19	19	6	5	3.3	.....	
Topeka	983	85	101	.....	.....	.....	49.2	+ 7.5	83	6	60	22	30	38	33	.....	.....	.....				0.43	− 0.8	4	9,060	s.	46	s.	10	15	8	7	4.0	T.	
Drexel	1,299	10	53	28.55	29.96	.....	41.5	.....	73	6	52	17	14	31	31	36	31	72				1.78	.....	4	8,736	nw.	54	sw.	10	12	9	9	4.9	.....	
Lincoln	1,189	11	84	28.68	29.97	− .11	44.2	+ 6.2	77	6	55	21	14	34	38	38	32	67				1.91	+ 1.1	4	8,358	nw.	42	nw.	19	13	10	7	4.4	T.	
Omaha	1,105	115	121	28.77	29.97	− .11	43.9	+ 6.2	75	6	53	20	29	35	30	38	32	66				1.51	+ 0.4	4	6,685	nw.	35	nw.	19	11	9	10	5.0	.....	
Valentine	2,598	47	54	27.22	29.99	− .09	37.8	+ 4.1	75	6	50	11	14	26	38	38	30	66				0.38	− 0.4	5	7,153	w.	34	nw.	7	15	9	6	4.6	0.3	
Sioux City	1,135	94	164	28.72	29.96	− .12	40.1	+ 5.8	72	6	49	17	29	31	32	35	30	72				0.85	− 0.1	3	9,581	nw.	55	nw.	22	10	9	11	5.3	0.5	
Huron	1,306	59	74	28.54	29.97	− .11	36.8	+ 9.4	71	6	48	12	14	26	34	31	27	74				0.25	− 0.3	1	8,852	nw.	44	nw.	8	10	11	9	5.2	T.	
Pierre	1,572	70	75	28.29	29.99	− .09	38.2	+ 6.6	72	5	48	12	29	28	33	32	24	62				0.84	+ 0.4	3	7,790	nw.	43	nw.	18	13	12	5	4.4	0.5	
Yankton	1,233	49	57	28.61	29.95	− .13	40.2	+ 6.7	74	6	50	17	29	30	32	.....	.....	.....				0.89	+ 0.1	4	6,261	nw.	37	nw.	19	8	13	9	5.9	0.6	

TABLE I.—*Climatological data for United States Weather Bureau stations, November, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
Northern Slope.							**34.9**	**+ 2.9**										**66**	**0.57**	**− 0.2**										**6.0**		
Havre	2,505	11	44	27.26	29.95	−0.08	32.4	+ 1.8	60	4	44	7	29	21	42	28	24	76	0.12	− 0.6	4	6,268	sw.	38	sw.	26	5	10	15	7.0	0.6	....
Helena	4,110	87	114	25.74	30.01	− .09	34.4	+ 1.7	56	3	42	11	13	27	30	30	23	62	0.29	− 0.4	6	7,214	sw.	47	sw.	18	4	18	8	6.1	3.1	....
Kalispell	2,962	11	34	26.90	30.02	− .05	32.2	+ 0.2	54	1	40	6	13	25	24	29	26	78	1.69	− 0.2	15	3,273	w.	29	s.	25	5	5	20	7.6	7.0	1.9
Miles City	2,371	26	48	27.42	30.02	− .05	38.4	+ 7.3	68	5	46	14	29	31	35	32	28	76	1.21	+ 0.6	10	3,438	w.	27	w.	18	15	11	4	3.9	1.2	....
Rapid City	3,259	50	58	26.53	30.02	− .06	37.0	+ 3.4	68	3	47	12	29	27	45	31	23	58	0.16	− 0.3	5	6,951	nw.	44	n.	18	8	11	11	5.5	0.3	....
Cheyenne	6,088	84	101	23.95	30.00	− .07	37.0	+ 2.1	67	2	47	9	13	27	36	29	20	54	0.19	− 0.2	5	13,191	w.	72	w.	22	7	12	11	5.6	1.9	T.
Lander	5,372	60	68	24.59	30.03	− .07	34.2	+ 5.5	67	5	49	1	28	19	43	28	19	56	0.10	− 0.5	3	5,026	sw.	42	nw.	18	7	16	7	5.3	1.0	....
Sheridan	3,790	10	47	26.05	30.04	.....	32.6	.....	69	4	45	− 3	13	20	44	28	22	69	1.03	.....	9	4,417	nw.	39	nw.	7	7	8	15	6.7	9.6	0.2
Yellowstone Park	6,200	11	48	23.82	30.07	− .04	27.2	− 2.1	56	2	36	− 4	13	18	26	24	19	69	1.15	− 0.3	13	6,707	s.	34	sw.	21	3	6	21	7.8	11.1	4.4
North Platte	2,821	11	51	27.05	30.02	− .06	41.2	+ 6.1	83	5	55	13	29	28	51	32	25	63	0.22	− 0.2	4	5,736	nw.	38	nw.	18	18	4	8	4.2	0.2	....
Middle Slope.							**47.6**	**+ 5.9**										**57**	**0.48**	**− 0.5**										**3.6**		
Denver	5,291	129	172	24.68	29.98	− .08	43.2	+ 4.0	79	3	56	10	28	31	36	33	20	45	0.24	− 0.3	5	7,143	sw.	42	nw.	18	14	12	4	4.2	3.8	....
Pueblo	4,685	80	86	25.26	30.00	− .05	42.8	+ 3.5	81	4	58	6	29	27	48	32	18	43	0.15	− 0.2	1	5,904	nw.	40	nw.	7	19	11	0	2.6	1.8	....
Concordia	1,392	50	58	28.50	29.99	− .09	47.0	+ 7.1	82	7	58	22	14	36	37	40	35	73	0.99	0.0	3	6,879	nw.	36	nw.	18	9	12	9	5.2	T.	....
Dodge	2,509	11	51	27.38	30.02	− .05	47.4	+ 6.9	81	3	63	11	29	32	44	36	29	61	0.08	− 0.5	2	8,120	s.	38	n.	25	16	12	2	3.4	.....	....
Wichita	1,358	139	158	28.53	29.97	− .11	51.1	+ 7.3	82	6	62	22	29	40	35	42	35	60	0.39	− 0.8	3	11,527	s.	54	sw.	10	21	5	4	3.1	.....	....
Oklahoma	1,214	10	47	28.73	30.03	− .05	53.8	+ 5.9	82	6	66	27	29	42	33	44	37	62	1.01	− 1.2	4	11,651	s.	46	s.	10	17	9	4	3.0	T.	....
Southern Slope.							**54.4**	**+ 3.5**										**47**	**0.05**	**− 1.2**										**2.9**		
Abilene	1,738	10	52	28.22	30.04	− .03	57.4	+ 4.8	85	7	71	22	29	44	41	45	35	52	T.	− 1.2	0	8,167	s.	45	s.	10	17	9	4	3.2	.....	....
Amarillo	3,676	10	49	26.26	30.02	− .03	49.5	+ 5.7	82	5	64	20	14	35	45	38	29	56	0.18	− 1.0	1	9,070	sw.	42	w.	10	28	0	2	2.8	1.8	....
Del Rio	944	64	71	29.06	30.05	.00	60.8	+ 1.5	84	10	73	28	29	49	38	.....	.....	.....	0.01	− 1.2	1	5,749	se.	50	nw.	25	16	11	3	3.5	.....	....
Roswell	3,566	75	85	26.39	30.03	.00	50.1	+ 2.0	83	5	68	18	29	32	49	36	18	34	T.	− 1.2	0	5,762	nw.	50	sw.	10	22	7	1	2.1	T.	....
Southern Plateau.							**51.8**	**0.0**										**38**	**0.23**	**− 0.4**										**2.4**		
El Paso	3,762	110	133	26.24	30.03	+ .03	52.8	+ 1.9	81	6	68	23	15	37	41	38	18	30	0.01	− 0.6	1	6,446	nw.	51	w.	10	21	9	0	2.0	.....	....
Santa Fe	7,013	57	62	23.27	30.08	+ .05	39.8	+ 1.6	68	5	51	13	28	28	31	29	18	46	0.61	− 0.2	4	6,703	n.	36	sw.	24	22	4	4	2.7	1.3	....
Flagstaff	6,908	8	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Phoenix	1,108	76	81	28.86	30.02	+ .04	59.2	+ 0.5	89	4	74	34	13	44	38	47	32	41	0.54	− 0.4	3	3,223	e.	26	nw.	24	19	9	2	2.9	.....	....
Yuma	141	9	54	29.88	30.03	+ .05	61.9	0.0	91	3	76	38	16	48	38	48	32	37	T.	− 0.3	0	4,424	n.	33	n.	13	28	1	1	1.1	.....	....
Independence	3,910	11	42	26.04	30.06	+ .01	45.2	− 4.0	74	1	60	15	14	30	42	.....	.....	.....	T.	− 0.3	0	3,615	se.	26	sw.	24	16	13	1	3.1	.....	....
Middle Plateau.							**40.1**	**+ 0.5**										**55**	**0.56**	**− 0.4**										**5.4**		
Reno	4,532	74	81	25.52	30.11	.00	42.5	+ 1.5	72	1	56	13	13	29	38	34	24	52	0.28	− 0.8	3	4,515	w.	55	w.	23	13	10	7	4.6	2.4	....
Tonopah	6,090	12	20	24.11	30.10	.....	40.9	.....	64	1	49	14	13	33	22	33	23	54	T.	− 0.9	0	6,767	se.	42	nw.	16	10	8	12	5.3	.....	....
Winnemucca	4,344	18	56	25.67	30.13	− .01	37.2	− 0.3	68	5	52	2	13	23	43	31	24	63	0.38	− 0.4	6	4,982	sw.	37	sw.	23	8	7	15	6.2	3.7	....
Modena	5,479	10	43	24.67	30.10	+ .02	38.0	− 1.0	71	4	52	9	28	24	42	29	18	50	0.54	− 0.1	4	7,623	w.	46	s.	9	11	12	7	4.5	T.	....
Salt Lake City	4,360	147	189	25.67	30.09	− .03	43.6	+ 3.2	74	4	52	19	14	35	28	36	27	56	1.61	+ 0.2	9	4,955	se.	39	nw.	16	5	9	16	6.5	5.2	....
Grand Junction	4,602	82	96	25.46	30.10	+ .02	39.2	− 0.7	71	5	50	11	28	28	33	32	24	58	0.71	+ 0.2	8	4,501	e.	43	w.	24	14	6	10	4.9	4.5	0.1
Northern Plateau.							**38.4**	**− 0.3**										**71**	**1.98**	**+ 0.6**										**8.2**		
Baker	3,471	48	53	26.49	30.14	− .02	32.4	− 2.5	62	4	41	3	13	24	28	30	26	77	2.14	+ 1.0	15	4,313	se.	26	s.	15	1	9	20	8.3	16.4	2.0
Boise	2,739	78	86	27.24	30.15	− .02	39.5	− 0.1	63	1	48	13	13	31	25	34	28	66	1.07	+ 0.2	13	3,718	nw.	27	se.	25	5	3	22	7.7	2.1	0.5
Lewiston	757	40	48	29.26	30.08	− .04	41.3	+ 0.4	63	1	48	22	13	34	21	.....	.....	.....	1.61	+ 0.3	16	2,780	e.	28	w.	21	3	4	23	8.3	1.5	....
Pocatello	4,477	46	54	25.30	30.10	− .04	37.6	+ 1.3	66	2	46	6	28	29	26	32	25	61	0.49	− 0.1	9	7,437	se.	36	sw.	24	4	7	19	7.4	2.3	0.5
Spokane	1,929	101	110	27.98	30.07	− .03	36.8	− 0.5	53	1	42	21	28	32	19	34	30	78	3.50	+ 1.2	14	4,431	sw.	32	sw.	21	1	3	26	9.0	10.4	0.8
Walla Walla	1,000	57	65	28.97	30.06	− .07	42.7	− 0.2	65	22	49	24	28	36	28	38	34	74	3.04	+ 0.9	17	3,817	s.	26	s.	22	1	9	20	8.3	2.6	....
North Pacific Coast Region.							**44.5**	**− 0.6**										**80**	**8.12**	**+ 0.8**										**8.5**		
North Head	211	11	56	29.80	30.03	− .02	46.6	− 1.1	56	4	50	38	27	43	11	45	43	89	8.68	+ 2.4	27	11,634	e.	82	s.	15	1	6	23	8.5	.....	....
Port Crescent	259	8	53	29.73	30.01	+ .01	40.3	− 2.0	54	4	47	29	9	34	20	.....	.....	.....	6.21	− 1.2	27	4,186	se.	34	sw.	25	0	7	23	8.0	.....	....
Seattle	125	215	250	29.92	30.05	+ .01	43.7	− 0.8	55	5	48	32	13	39	14	41	39	84	5.66	− 0.2	22	7,357	se.	52	sw.	25	1	5	24	8.6	.....	....
Tacoma	213	113	120	29.82	30.05	+ .01	43.0	− 1.1	55	4	48	29	27	38	14	41	39	86	8.13	− 0.4	22	4,735	sw.	36	sw.	21	0	8	22	8.5	.....	....
Tatoosh Island	109	7	57	29.87	29.96	− .01	45.1	− 0.8	53	3	49	36	11	42	11	43	41	48	8.30	− 3.8	26	13,407	e.	74	sw.	25	1	9	20	8.2	.....	....
Portland, Oreg.	153	68	106	29.90	30.06	− .04	45.4	− 0.2	59	18	50	32	27	41	14	43	41	85	11.32	+ 4.8	24	4,124	s.	37	w.	25	0	2	28	9.6	.....	....
Roseburg	510	9	57	29.56	30.12	.00	47.4	+ 1.8	67	22	54	33	7	41	29	45	42	84	8.54	+ 4.2	25	1,926	s.	30	sw.	15	0	16	14	7.6	.....	....
Middle Pacific Coast Region.							**52.2**	**− 0.9**										**73**	**1.87**	**− 1.3**										**5.0**		
Eureka	62	73	89	30.10	30.17	+ .06	49.8	− 1.2	65	22	57	33	13	43	19	48	46	87	6.15	+ 0.5	18	4,200	se.	34	sw.	25	7	5	18	7.1	.....	....
Mount Tamalpais	2,375	11	18	27.66	30.15	+ .06	48.9	− 1.7	70	1	54	34	10	44	17	43	38	71	1.28	− 2.4	8	11,397	nw.	62	n.	26	10	7	13	5.4	.....	....
Point Reyes Light	490	7	18	29.58	30.10	.....	53.2	+ 0.2	66	19	57	44	9	49	16	.....	.....	.....	0.72	.....	4	11,220	nw.	64	nw.	6	13	6	11	4.8	.....	....
Red Bluff	332	50	56	29.76	30.13	+ .02	51.6	− 1.8	76	1	60	33	14	43	29	46	40	66	1.83	− 1.4	6	3,148	nw.	29	s.	25	12	6	12	5.3	.....	....
Sacramento	69	106	117	30.06	30.13	+ .04	53.0	− 0.4	80	1	62	34	27	44	28	48	42	69	0.83	− 1.3	5	4,274	se.	27	s.	8	11	9	10	4.8	.....	....
San Francisco	155	209	213	29.97	30.14	+ .05	56.1	+ 0.6	75	1	63	45	14	50	22	50	46	73	0.92	− 1.6	7	4,266	n.	27	sw.	8	14	12	4	3.6	.....	....
San Jose	141	12	110	29.99	30.14	.....	52.6	− 1.8	80	1	64	30	14	41	33	.....	.....	.....	0.19	− 1.7	4	3,515	se.	24	se.	8	14	12	4	3.8	.....	....
South Pacific Coast Region.							**58.3**	**+ 1.2**										**62**	**0.68**	**− 0.4**										**3.4**		
Fresno	327	89	98	29.78	30.14	+ .08	53.8	− 0.8	82	1	66	32	13	42	37	46	38	60	0.30	− 0.7	3	3,598	nw.	23	nw.	24	15	12	3	3.4	.....	....
Los Angeles	338	159	191	29.70	30.06	+ .04	61.8	+ 3.4	88	19	72	44	23	52	29	52	44	61	1.35	− 0.1	3	4,000	sw.	24	nw.	16	17	8	5	3.3	.....	....
San Diego	87	62	70	29.95	30.04	+ .02	59.6	+ 0.6	81	17	69	42	14	50	32	52	46	68	0.73	− 0.1	4	3,373	nw.	26	nw.	10	19	10	1	2.7	.....	....
San Luis Obispo	201	32	40	29.91	30.13	+ .07	58.1	+ 1.8	84	19	69	34	22	47	39	49	42	61	0.34	− 1.4	3	3,055	n.	20	n.	27	15	8	7	4.0	.....	....
West Indies.																																	
San Juan	82	8	54	29.88	29.96	+ .06	79.2	.....	93	1	84	70	27	74	17	.....	.....	.....	13.29	+ 6.4	18	9,038	ne.	46	ne.	13	10	9	11	5.6	.....	....
Panama.																																	
Balboa Heights	118	7	97	29.73	29.85	.....	78.8	.....	87	17	84	70	11	73	17	75	74	96	7.05	−3.22	24	3,906	nw.	24	ne.	17	0	2	28	9.1	.....	....
Colon	25	5	71	29.83	29.85	.....	80.4	.....	89	3	86	74	27	75	15	76	75	90	22.32	+0.65	27	5,354	se.	30	ne.	9	1	8	21	7.9	.....	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during November, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	25			T.														T.			
Albany, N. Y.	29			0.65														0.16			
Alpena, Mich.	18–20			1.19														.22			
Amarillo, Tex.	17			0.18														*			
Anniston, Ala.	14–15			1.10														.63			
Asheville, N. C.	26	5:10 p. m.	9:35 p. m.	0.53	7:38 p. m.	7:48 p. m.	0.10	0.20	0.31												
Atlanta, Ga.	18	7:15 a. m.	5:20 p. m.	0.52	3:39 p. m.	3:55 p. m.	.09	.17	.22	0.36	0.38										
Atlantic City, N. J.	19			0.56														.16			
Augusta, Ga.	18			2.22														.53			
Baker, Oreg.	25			0.63														*			
Baltimore, Md.	19			0.99														.29			
Bentonville, Ark.	25			1.37														.76			
Binghamton, N. Y.	19			0.47														.20			
Birmingham, Ala.	14–15	6:59 p. m.	D. N. a. m.	1.05	7:08 p. m.	7:28 p. m.	.01	.14	.27	.43	.50										
Bismarck, N. Dak.	7			0.40														.20			
Block Island, R. I.	19			1.03														.40			
Boise, Idaho.	23			0.15														.10			
Boston, Mass.	19			0.83														.35			
Buffalo, N. Y.	16–17			0.67														*			
Burlington, Vt.	14–15			0.63														*			
Cairo, Ill.	25–26	8:30 p. m.	D. N. a. m.	1.34	10:35 p. m.	10:49 p. m.	.01	.12	.28	.36											
Canton, N. Y.	15			0.55														.09			
Charles City, Iowa.	10	4:10 a. m.	5:00 p. m.	1.23	9:11 a. m.	9:35 a. m.	.49	.13	.20	.31	.41	0.46									
Charleston, S. C.	18	9:48 a. m.	8:50 p. m.	1.49	6:10 p. m.	6:30 p. m.	.91	.06	.17	.39	.52										
Charlotte, N. C.	18			0.99														.25			
Chattanooga, Tenn.	14–15	2:54 p. m.	2:09 a. m.	1.61	6:20 p. m.	6:29 p. m.	.61	.31	.43												
Cheyenne, Wyo.	20			0.09														*			
Chicago, Ill.	18–19			1.26														.20			
Cincinnati, Ohio.	18–19			1.30														.20			
Cleveland, Ohio.	19			0.58														.23			
Columbia, Mo.	25–26	2:12 p. m.	2:24 p. m.	1.66	3:12 p. m.	3:33 p. m.	.07	.14	.34	.50	.59	.63									
Columbia, S. C.	18			1.74														.51			
Columbus, Ohio.	18–19			0.92														.25			
Concord, N. H.	19			1.27														.33			
Concordia, Kans.	10	7:34 p. m.	10:35 p. m.	0.77	7:49 p. m.	8:02 p. m.	.03	.07	.35	.40											
Corpus Christi, Tex.	17			0.16														.16			
Davenport, Iowa.	26			1.90														*			
Dayton, Ohio.	18–19			1.45														.19			
Del Rio, Tex.	24			0.01														.01			
Denver, Colo.	10			0.09														*			
Des Moines, Iowa.	10–11			0.87														.16			
Detroit, Mich.	18–19			1.45														.28			
Devils Lake, N. Dak.	7–8			0.35														.08			
Dodge City, Kans.	10			0.06														.04			
Dubuque, Iowa.	25			0.80														*			
Duluth, Minn.	26–27			0.27														*			
Durango, Colo.																					
Eastport, Me.	29–30			0.49														.27			
Elkins, W. Va.	14–15			1.61														.19			
El Paso, Tex.	6			0.01														*			
Erie, Pa.	14–15			0.48														*			
Escanaba, Mich.	10			1.27														.28			
Eureka, Cal.	23–24			2.61														.54			
Evansville, Ind.	11			0.97														.42			
Flagstaff, Ariz.																					
Fort Smith, Ark.	13–14			0.55														.43			
Fort Wayne, Ind.	18–19			0.91														*			
Fort Worth, Tex.	14			0.26														.14			
Fresno, Cal.	9			0.21														.11			
Galveston, Tex.	17–18			0.40														*			
Grand Haven, Mich.	18–19			0.88														*			
Grand Junction, Colo.	6–7			0.15														*			
Grand Rapids, Mich.	18–19			0.87														.11			
Green Bay, Wis.	11			0.26														.24			
Hannibal, Mo.	25–26	3:40 p. m.	3:25 p. m.	2.18	4:37 p. m.	4:54 p. m.	.03	.09	.26	.43	.50										
Harrisburg, Pa.	19			0.50														.15			
Hartford, Conn.	19			0.56														.17			
Hatteras, N. C.	18–19			0.59														.24			
Havre, Mont.	23			0.05														.05			
Helena, Mont.	12			0.19														*			
Houghton, Mich.	7	9:13 a. m.	D. N. p. m.	1.52	2:12 p. m.	2:47 p. m.	.38	.09	.18	.26	.36	.46	0.56	0.62							
Houston, Tex.	25			0.40														.37			
Huron, S. Dak.	7			0.25														.16			
Independence, Cal.	23			T.														T.			
Indianapolis, Ind.	18–19			1.68														.40			
Iola, Kans.	25			0.18														.14			
Jacksonville, Fla.	18	9:00 a. m.	4:10 p. m.	0.60	2:57 p. m.	3:05 p. m.	.22	.17	.34												
Kalispell, Mont.	25			0.34														*			
Kansas City, Mo.	25			0.49														.33			
Keokuk, Iowa.	25–26			1.88														.35			
Key West, Fla.	15			0.80														.44			
Knoxville, Tenn.	14–15			2.86														.47			
La Crosse, Wis.	10–11			1.13														.35			
Lander, Wyo.	20			0.04														*			
Lansing, Mich.	11	10:05 a. m.	7:15 p. m.	0.60	5:00 p. m.	5:17 p. m.	.08	.23	.41	.47	.50										
Lewiston, Idaho.	11			0.33														*			
Lexington, Ky.	11–12			0.70														.24			
Lincoln, Nebr.	10	9:05 a. m.	10:55 a. m.	0.88	9:41 a. m.	10:11 a. m.	.25	.09	.22	.31	.47	.50	.57								
Little Rock, Ark.	25	4:50 p. m.	D. N. p. m.	1.92	4:59 p. m.	6:15 p. m.	.01	.18	.47	.60	.79	.91	.94	.99	1.09	1.12	1.19	1.36	1.56		
Los Angeles, Cal.	5–6			1.13														.13			
Louisville, Ky.	18			1.25														.25			
Ludington, Mich.	18–19			1.05														*			
Lynchburg, Va.	18–19			1.43														.46			
Macon, Ga.	26	5:40 p. m.	6:50 p. m.	0.62	5:59 p. m.	6:25 p. m.	.01	.16	.35	.45	.50	.59	.60								
Madison, Wis.	25–26			1.37														.33			
Marquette, Mich.	10–11			0.61														.22			
Memphis, Tenn.	25–26	9:57 p. m.	D. N. a. m.	1.46	10:02 p. m.	10:44 p. m.	.01	.13	.23	.31	.42	.52	.60	.65	.75	.82					
Meridian, Miss.	26	D. N. a. m.	5:10 a. m.	0.88	2:34 a. m.	2:46 a. m.	.06	.22	.36	.40											
Miami, Fla.	15–16			2.22														.64			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during November, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Milwaukee, Wis.	18-19			0.65														*			
Minneapolis, Minn.	7	3:20 p. m.	6:10 p. m.	1.62	4:42 p. m.	5:23 p. m.	0.30	0.19	0.36	0.45	0.48	0.56	0.65	0.93	1.05	1.08					
Mobile, Ala.	18	D. N. a. m.	8:30 a. m.	1.33	7:27 a. m.	8:06 a. m.	.23	.06	.11	.22	.29	.46	.67	.97	1.07						
	23	D. N. a. m.	4:50 a. m.	1.03	3:14 a. m.	4:07 a. m.	.09	.07	.10	.12	.22	.27	.33	.54	.63	.67	0.71	0.79			
Modena, Utah	6			0.44														.11			
Montgomery, Ala.	18	6:55 a. m.	1:40 p. m.	0.79	11:30 a. m.	12:12 p. m.	.03	.07	.25	.35	.38	.41	.45	.52	.64	.69					
	26	8:07 a. m.	9:55 a. m.	0.78	8:13 a. m.	8:44 a. m.	.01	.08	.27	.36	.46	.52	.62	.68							
Moorhead, Minn.	7			0.58														.30			
Mount Tamalpais, Cal.	8-9			0.62														.23			
Nantucket, Mass.	19			0.74														*			
Nashville, Tenn.	13-14	10:10 p. m.	1:05 p. m.	3.39	5:13 a. m.	6:07 a. m.	1.02	.08	.13	.16	.22	.42	.50	.51	.62	.67	.73	.83			
New Haven, Conn.	19			1.10														.42			
New Orleans, La.	26			1.17														*			
New York, N. Y.	14-15			0.50														.11			
Norfolk, Va.	18-19			0.63														.27			
Northfield, Vt.	14-15			0.50														*			
North Head, Wash.	28			1.19														.23			
North Platte, Nebr.	10			0.18														.10			
Oklahoma, Okla.	10	10:23 p. m.	10:45 p. m.	0.31	10:25 p. m.	10:31 p. m.	.01	.28	.30												
Omaha, Nebr.	10	8:30 p. m.	D. N. p. m.	0.91	8:33 p. m.	8:45 p. m.	.01	.21	.34	.42											
Oswego, N. Y.	19			0.59														*			
Palestine, Tex.	17	3:45 p. m.	6:40 p. m.	0.60	5:45 p. m.	6:08 p. m.	.10	.10	.25	.34	.45	.49									
Parkersburg, W. Va.	14-15			1.60														.17			
Pensacola, Fla.	18	3:05 a. m.	12:05 p. m.	2.19	9:31 a. m.	10:16 a. m.	.13	.29	.66	1.13	1.42	1.56	1.69	1.82	1.88	1.94					
Peoria, Ill.	25-26			1.33														.32			
Philadelphia, Pa.	19			0.40														.20			
Phoenix, Ariz.	5-6			0.46														.13			
Pierre, S. Dak.	7			0.69														.20			
Pittsburgh, Pa.	19-20			0.48														.20			
Pocatello, Idaho	24			0.12														.08			
Point Reyes Light, Cal.	8			0.39														*			
Port Huron, Mich.	18-20			1.31														.18			
Portland, Me.	19			1.24														.33			
Portland, Oreg.	22-23			2.33														.33			
Providence, R. I.	29			0.29														.26			
Pueblo, Colo.	27			0.15														*			
Raleigh, N. C.	18			0.67														.31			
Rapid City, S. Dak.	7			0.08														.06			
Reading, Pa.	19			1.06														.29			
Red Bluff, Cal.	8			1.23														.36			
Reno, Nev.	9			0.15														*			
Richmond, Va.	18-19			0.38														.10			
Rochester, N. Y.	19			0.79														.15			
Roseburg, Oreg.	15			1.14														.20			
Roswell, N. Mex.	25			T.														T.			
Sacramento, Cal.	8-9			0.68														*			
Saginaw, Mich.	11	3:15 p. m.	6:21 p. m.	0.49	4:58 p. m.	5:11 p. m.	.06	.16	.30	.36											
St. Joseph, Mo.	27			0.24														0.9			
St. Louis, Mo.	25-26			0.85														.35			
St. Paul, Minn.	10-11			1.51														*			
Salt Lake City, Utah	6-7			0.74														*			
San Antonio, Tex.	13			0.13														.11			
San Diego, Cal.	5-6			.36														.11			
Sand Key, Fla.	15-16			0.99														.26			
Sandusky, Ohio	18-19			0.99														.19			
San Francisco, Cal.	8			0.47														.18			
San Jose, Cal.	8			0.11														.09			
San Luis Obispo, Cal.	8			0.16														.13			
Santa Fe, N. Mex.	6-7			0.39														.12			
Sault Ste. Marie, Mich.	10-11			1.53														*			
Savannah, Ga.	18			1.43														.33			
Scranton, Pa.	8			0.21														.13			
Seattle, Wash.	22			0.72														.15			
Sheridan, Wyo.	20			0.40														*			
Shreveport, La.	8-9	11:20 p. m.	D. N. a. m.	0.98	11:23 p. m.	11:43 p. m.	.01	.24	.49	.74	.80										
Sioux City, Iowa	10-11			0.83														.27			
Spokane, Wash.	21			0.47														*			
Springfield, Ill.	25-26			0.61														.22			
Springfield, Mo.	25	11:42 a. m.	8:02 p. m.	1.36	2:12 p. m.	2:43 p. m.	.16	.08	.13	.21	.47	.62	.68	.72							
Syracuse, N. Y.	19			0.44														*			
Tacoma, Wash.	24-26			1.49														*			
Tampa, Fla.	18	12:35 p. m.	1:45 p. m.	0.43	12:55 p. m.	1:10 p. m.	.07	.10	.27	.36											
		3:50 p. m.	10:00 p. m.	1.15	6:48 p. m.	7:19 p. m.	.31	.09	.14	.21	.26	.49	.59	.63							
Tatoosh Island, Wash.	21			1.16														.51			
Taylor, Tex.	14			0.52														.21			
Terre Haute, Ind.	11			1.34														.58			
Thomasville, Ga.	18			1.29														.35			
Toledo, Ohio	18-19			1.29														.23			
Tonopah, Nev.	26			T.														T.			
Topeka, Kans.	10-11			0.36														.23			
Valentine, Nebr.	7			0.23														.19			
Vicksburg, Miss.	14	2:00 p. m.	7:30 p. m.	2.03	2:29 p. m.	2:46 p. m.	.01	.26	.40	.53	.56										
					3:26 p. m.	3:53 p. m.	.73	.12	.33	.47	.56	.62	.70								
	25-26	9:10 p. m.	D. N. a. m.	1.19	9:48 p. m.	10:17 p. m.	.02	.20	.36	.47	.59	.73	.83								
Walla Walla, Wash.	17			0.68														*			
Washington, D. C.	18-19			0.55														.24			
Wichita, Kans.	10			0.24														.23			
Williston, N. Dak.	7			1.69														.17			
Wilmington, N. C.	18			0.71														.29			
Winnemucca, Nev.	23-24			0.24														*			
Wytheville, Va.	15			0.25							*							*			
Yankton, S. Dak.	10-11			0.61														.27			
Yellowstone Park, Wyo.	24			0.29														*			

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, November, 1915.*

Stations.	Pressure.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea-level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	29.61	29.75	−0.19	40.4	+3.9	44.4	36.4	54	30	8.45	+2.88	T.
Sydney, C. B. I.	29.78	29.82	− .13	41.4	+4.3	46.7	36.1	58	24	8.38	+2.94	.....
Halifax, N. S.	29.75	29.86	− .05	42.3	+5.0	48.7	35.9	65	28	6.56	+0.90	2.4
Yarmouth, N. S.	29.80	29.87	− .05	41.5	+1.6	45.5	37.4	55	28	3.98	−0.68	.....
Charlottetown, P. E. I.	29.81	29.85	− .11	39.4	+3.9	43.3	35.4	54	22	4.67	+0.70	3.0
Chatham, N. B.	29.89	29.91	− .06	35.6	+4.6	40.4	30.7	52	15	3.16	−0.59	5.1
Father Point, Que.	29.89	29.91	− .05	31.6	+2.7	36.3	26.8	46	12	2.09	−1.02	9.2
Quebec, Que.	29.61	29.95	− .07	32.6	+3.6	37.3	27.9	50	19	2.23	−1.53	8.5
Montreal, Que.	29.73	29.95	− .08	35.4	+3.6	40.7	30.1	64	21	2.34	−1.40	2.0
Stonecliffe, Ont.	29.31	29.94	− .07	33.4	+4.3	39.0	27.8	59	9	0.97	−1.68	3.3
Ottawa, Ont.	29.68	30.01	− .01	35.6	+3.9	41.7	29.5	61	16	1.55	−0.99	3.4
Kingston, Ont.	29.68	30.00	− .04	40.2	+4.8	46.5	33.9	63	20	0.89	−2.35	T.
Toronto, Ont.	29.54	29.93	− .11	40.7	+5.1	46.5	34.8	61	24	1.89	−1.35	2.9
White River, Ont.	29.45	29.79	− .19	26.7	+6.2	33.8	19.6	55	− 9	3.49	+0.35	17.0
Port Stanley, Ont.	29.30	29.96	− .09	40.4	+3.6	47.7	33.1	54	12	2.95	+1.10	1.9
Southampton, Ont.	29.19	.....	.....	39.9	+4.9	46.5	33.3	66	16	3.48	+0.11	5.9
Parry Sound, Ont.	29.20	29.90	− .11	37.4	+5.3	44.1	30.7	58	12	3.64	−0.06	11.6
Port Arthur, Ont.	29.13	29.86	− .14	32.2	+2.2	38.1	26.3	54	12	2.45	+1.12	0.7
Winnipeg, Man.	29.05	29.91	− .13	24.6	+6.6	30.9	18.2	53	− 2	1.16	+0.08	9.6
Minnedosa, Man.	28.03	29.90	− .14	21.5	+4.2	29.1	13.9	60	− 5	1.01	+0.01	10.1
Qu'Appelle, Sask.	27.55	29.85	− .15	23.7	+4.9	32.2	15.2	55	− 8	1.70	+0.81	17.0
Medicine Hat, Alberta	27.53	29.85	− .15	32.3	+4.9	42.3	22.3	63	0	0.09	−0.83	0.8
Swift Current, Sask.	27.24	29.87	− .15	27.5	+4.3	38.6	16.3	57	− 2	0.10	−0.59	0.7
Calgary, Alberta	26.26	29.86	− .12	29.1	+3.3	39.6	18.6	55	0	0.47	−0.41	4.7
Banff, Alberta	25.24	29.97	+ .01	25.2	−2.6	30.2	16.1	42	− 8	0.48	−1.79	4.6
Edmonton, Alberta	27.49	29.84	− .13	25.4	+2.5	34.7	16.0	53	3	0.60	+0.02	6.0
Prince Albert, Sask.	28.24	29.85	− .18	18.7	+3.3	25.5	11.9	44	−14	0.94	−0.11	9.4
Battleford, Sask.	28.10	29.90	− .12	21.1	+4.8	31.6	10.6	51	−12	0.30	−0.28	3.0
Kamloops, B. C.	28.72	30.04	+ .08	33.3	−0.1	39.8	26.8	54	13	0.38	−0.40	0.8
Victoria, B. C.	29.74	29.84	− .15	43.3	+0.1	47.4	39.2	54	33	4.57	−2.40	.....
Barkerville, B. C.	25.48	29.87	− .03	20.7	−2.9	28.3	13.2	37	0	3.05	−0.12	30.5
Hamilton, Bermuda	29.91	30.07	− .02	66.6	−2.1	71.9	61.3	76	56	3.04	−1.34	.....

Chart I. Hydrographs of Several Principal Rivers, November, 1915.

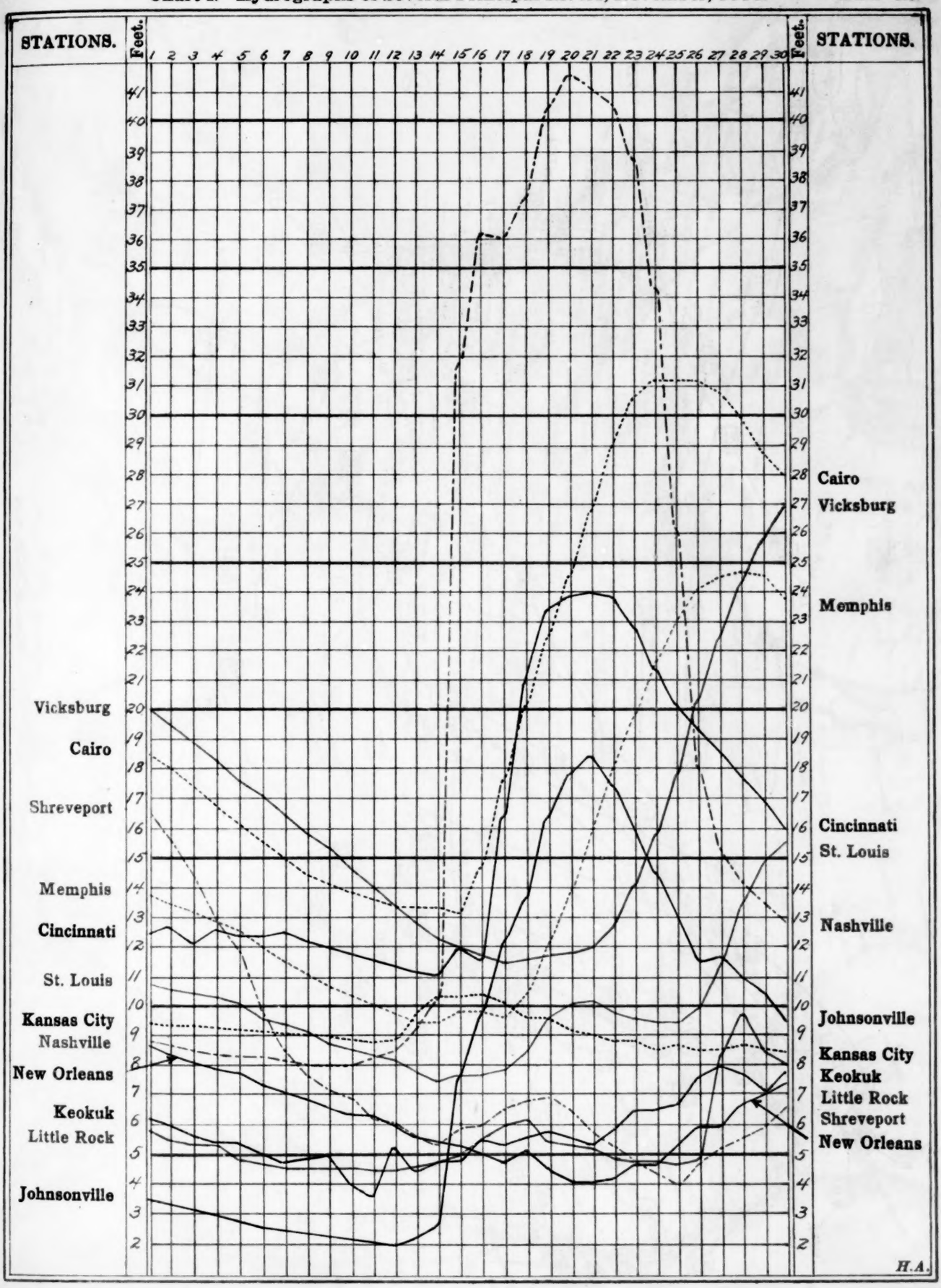

Chart II. Tracks of Centers of High Areas, November, 1915.

(Plotted by R. H. Weightman.)

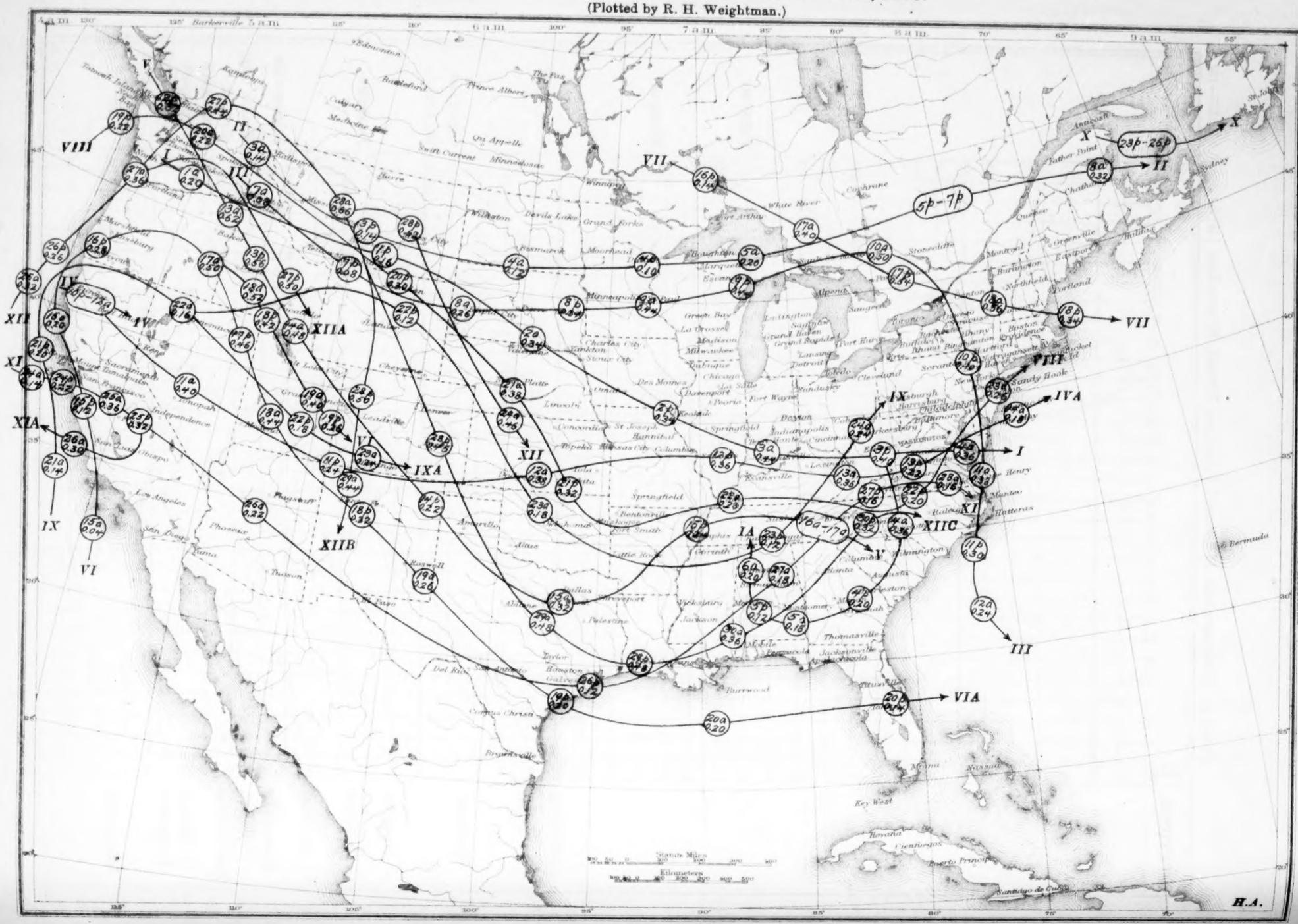

Chart III. Tracks of Centers of Low Areas, November, 1915.

(Plotted by R. H. Weightman.)

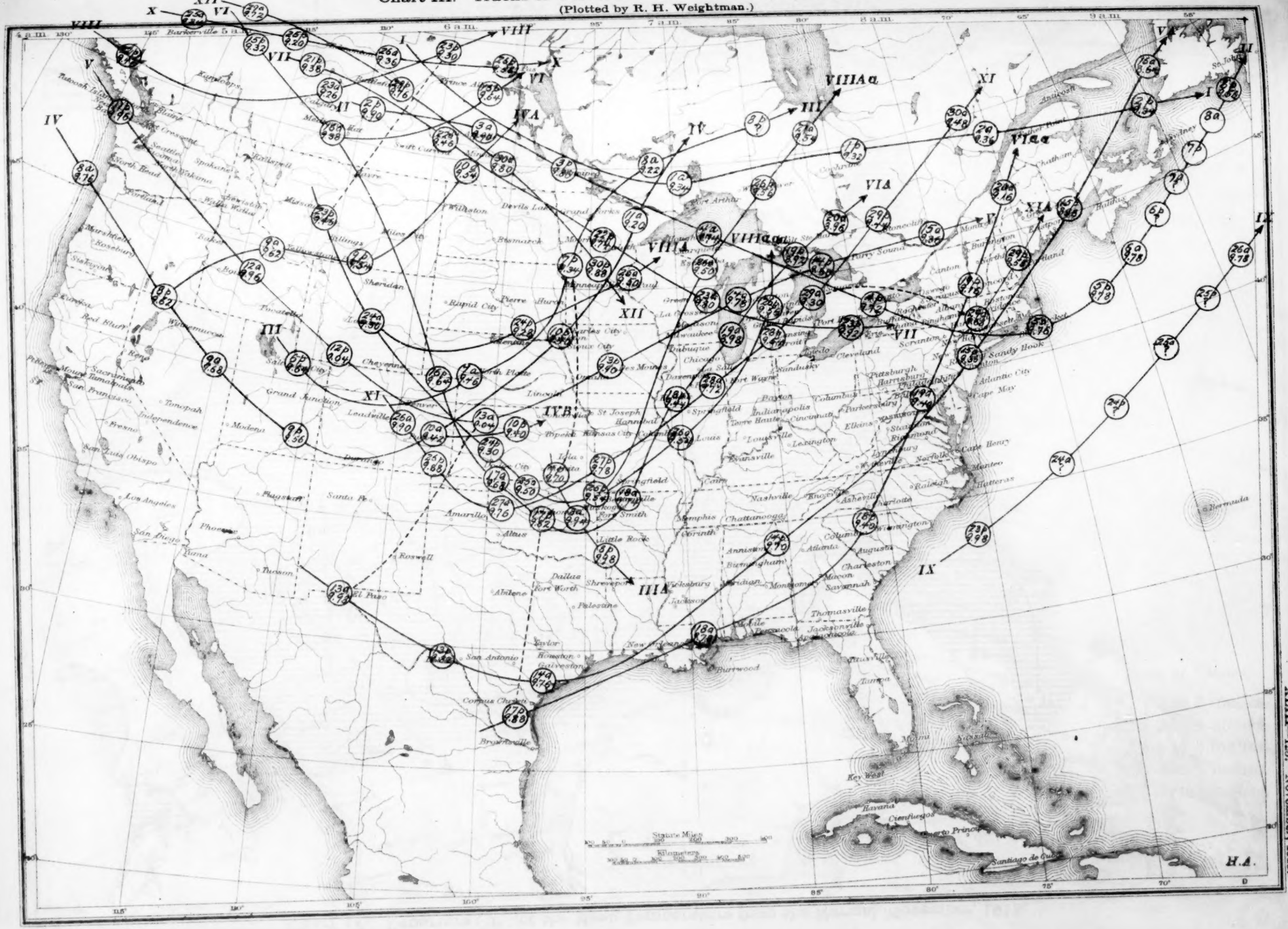

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, November, 1915.

Chart V. Total Precipitation, Inches, November, 1915.

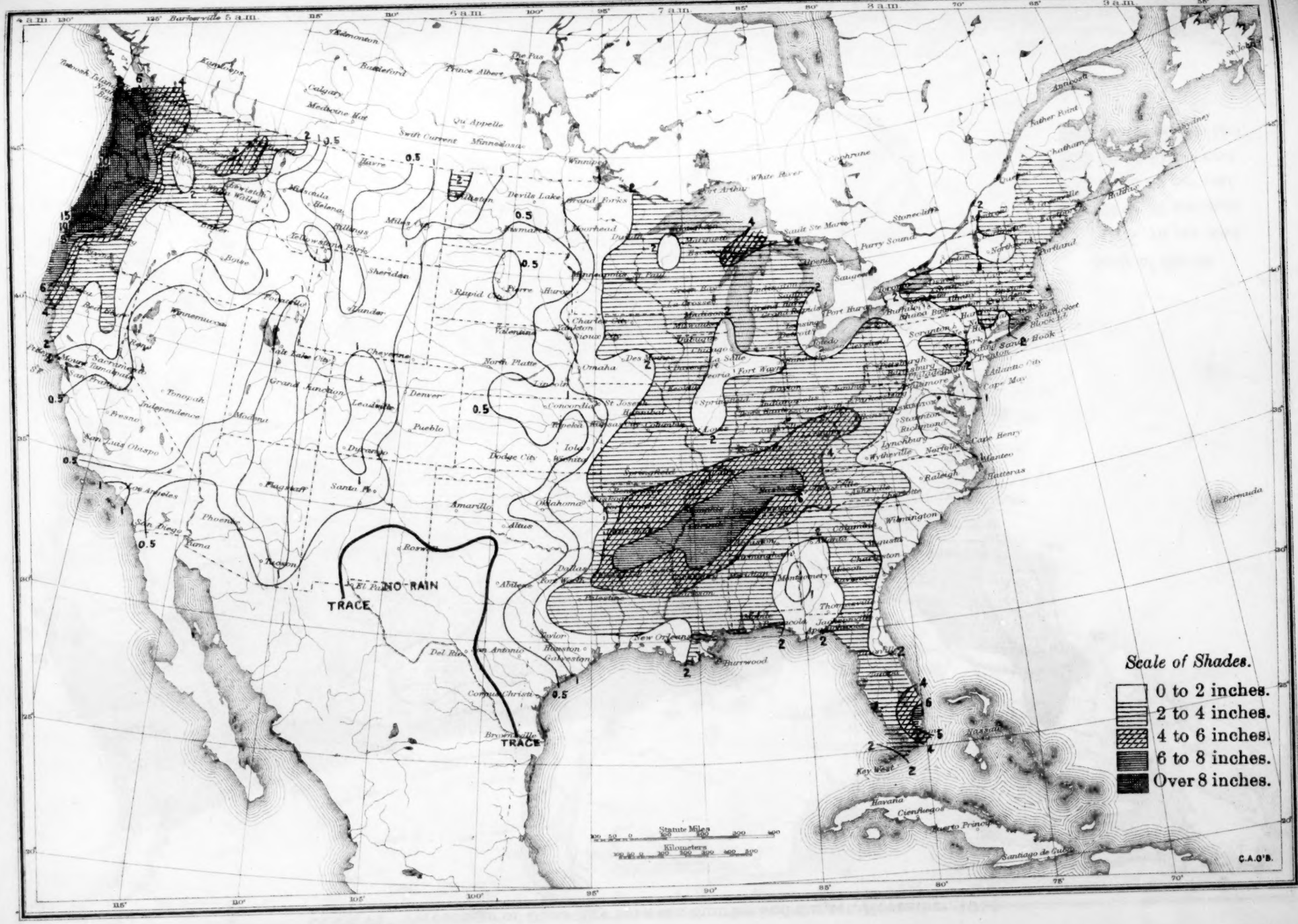

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, November, 1915.

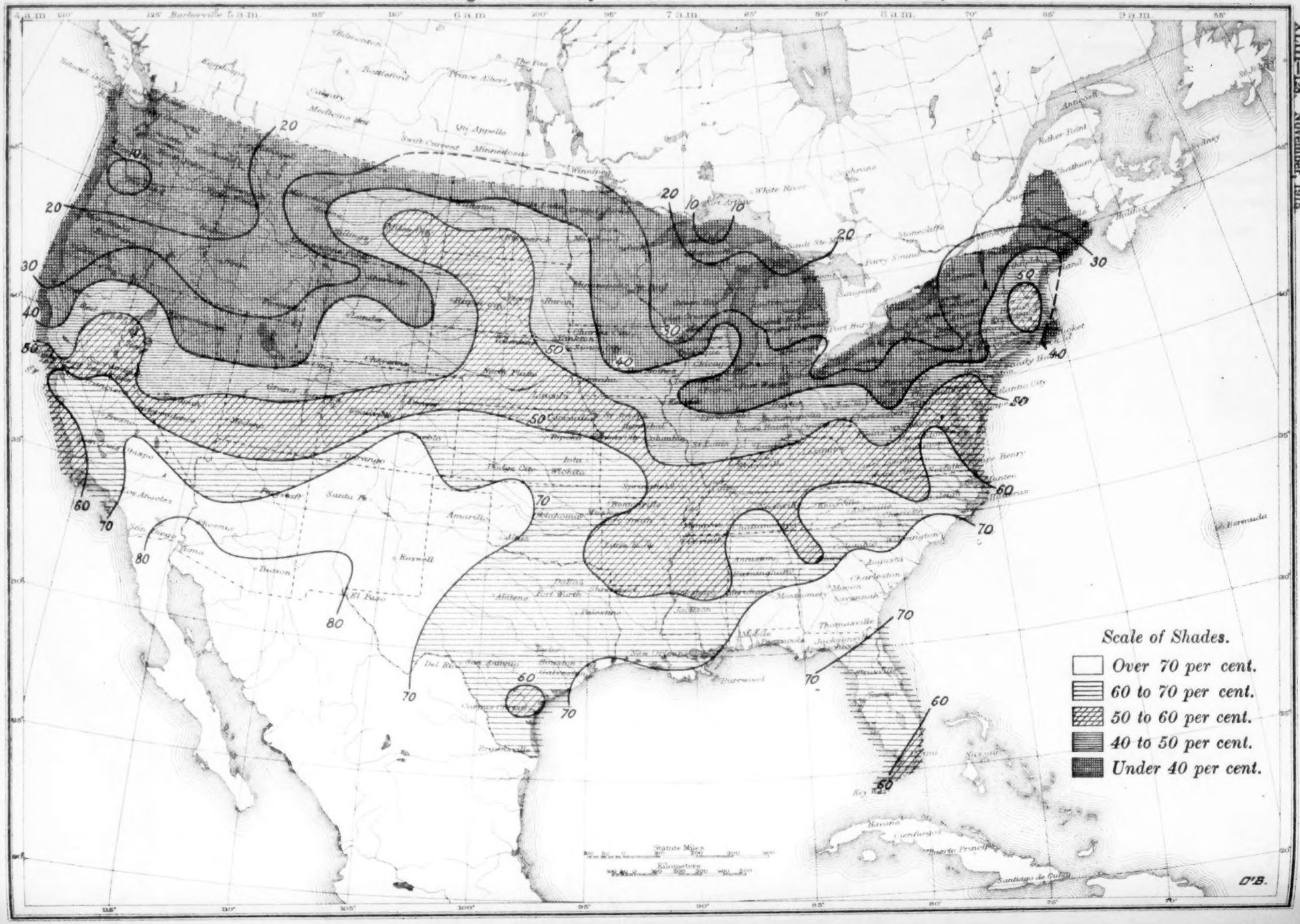

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, November, 1915.

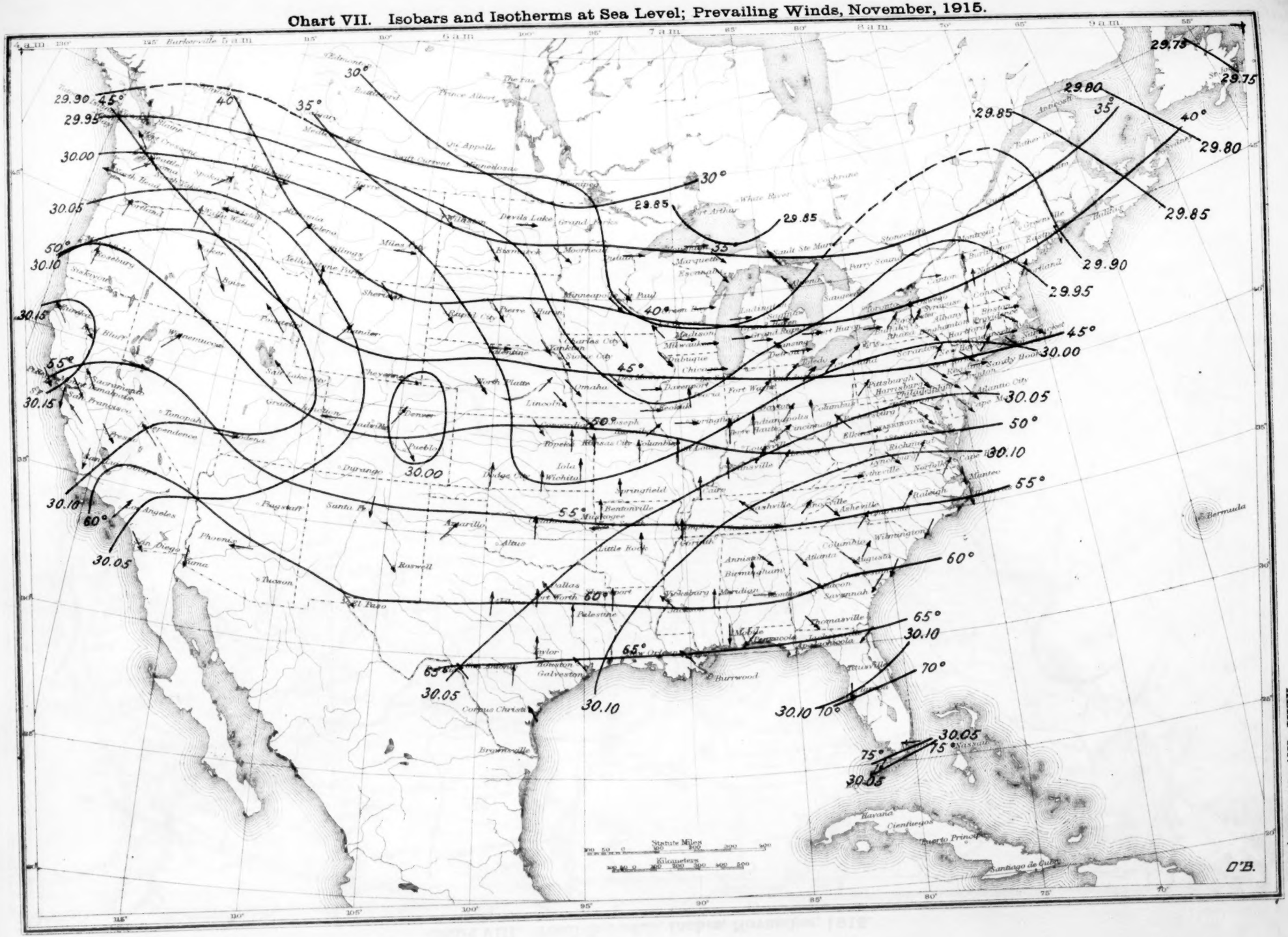

Chart VIII. Total Snowfall, Inches, November, 1915.

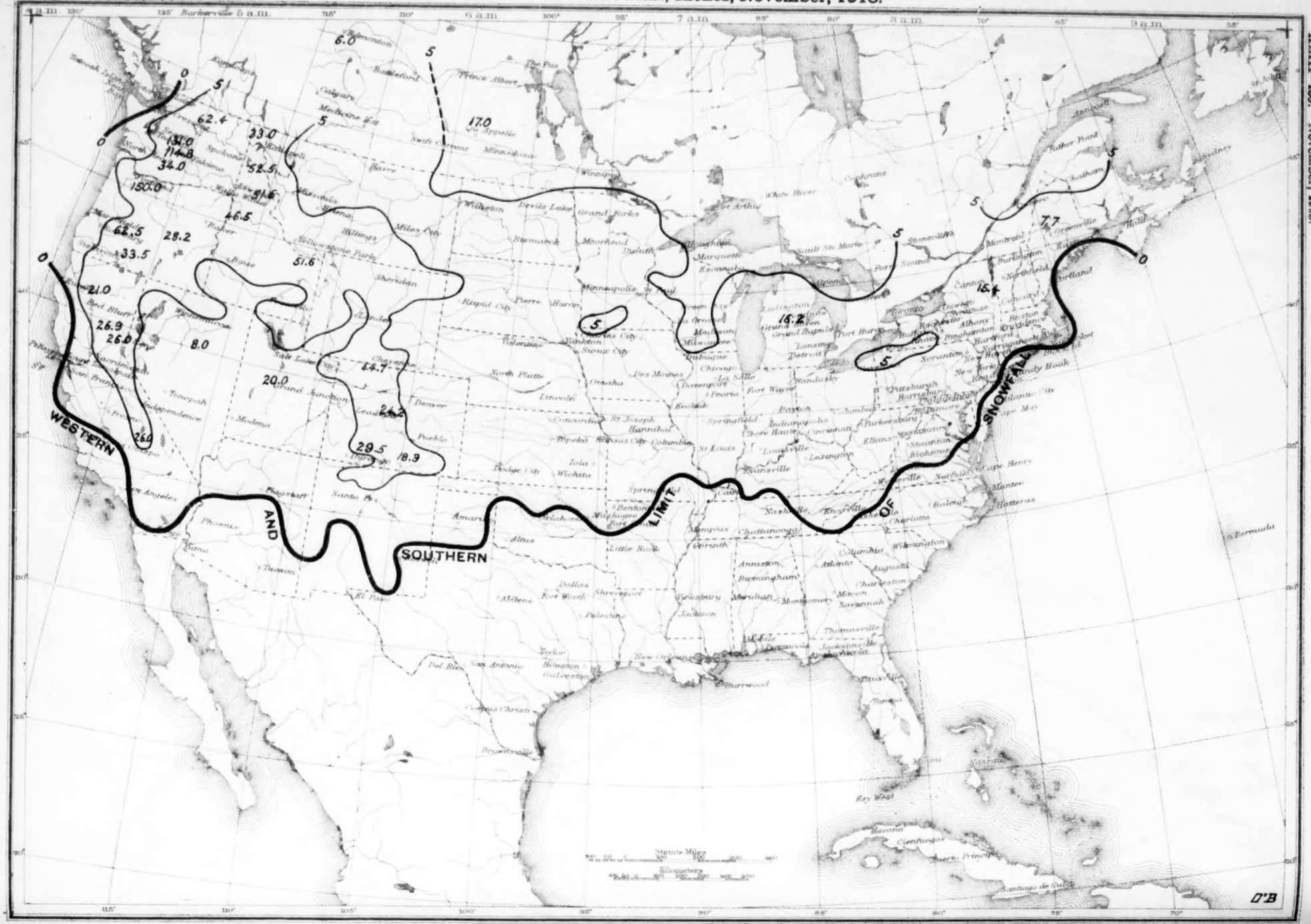
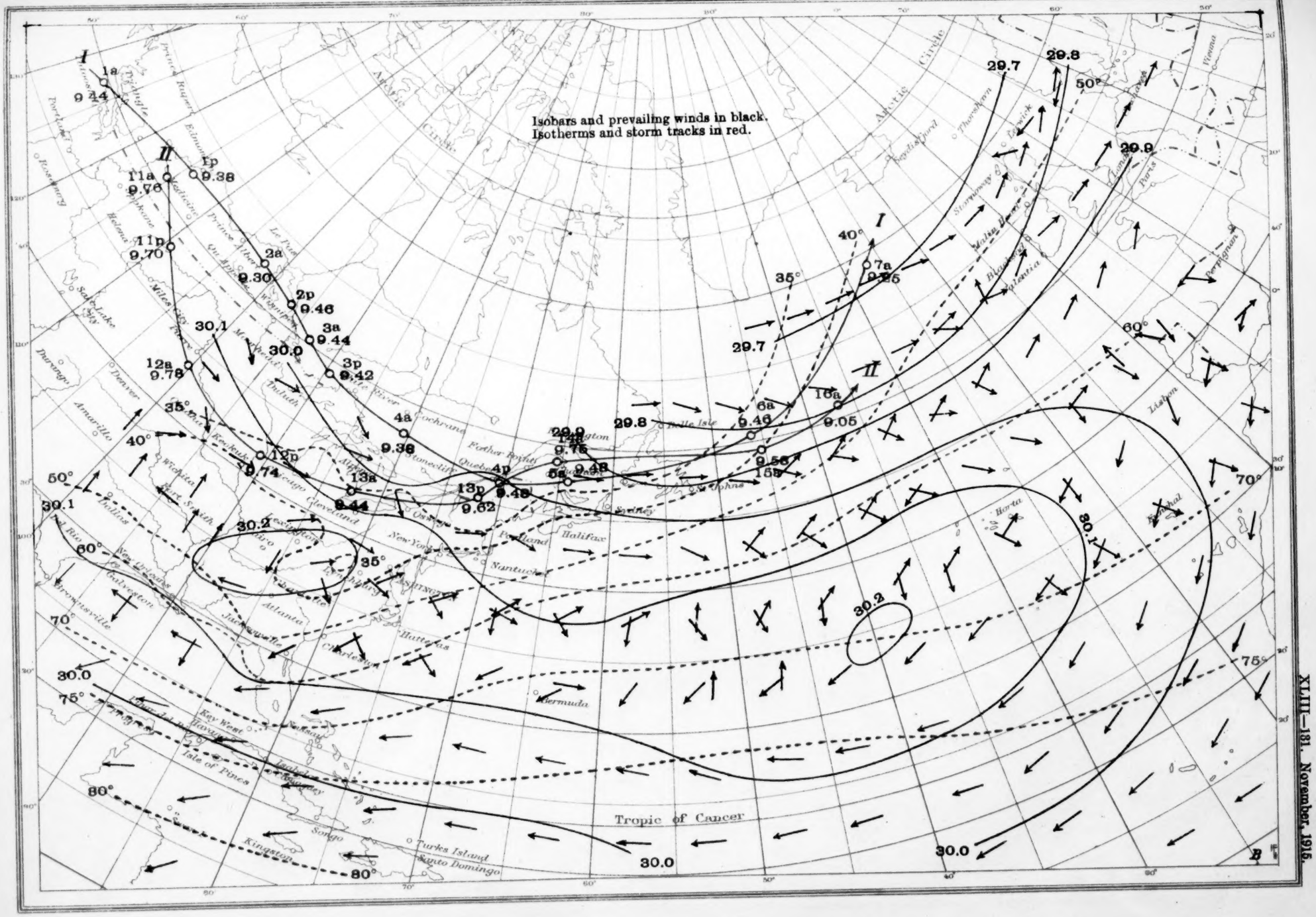
Chart IX. Means of Meteorological Data for North Atlantic Ocean, November, 1914.